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Pasture Production

PASTURE PRODUCTION

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INTRODUCTION

When Cato, the Roman philosopher, was asked over 2,000 years ago what was the most profitable thing a farmer could have, he replied, "A first-class pasture." Somewhat startled, his questioners then asked what the second most prized possession would be. "A second-class pasture," was his ready reply.

– W.H. Kennedy. Pasture Improvement and Management, Cornell Extension Bull. 979.

In Ontario, livestock producers use almost a half of a million hectares of improved pasture and three-quarters of a million hectares of unimproved pastureland. The combined area provides the cheapest source of nutrition for beef and dairy cattle, sheep, goats, horses, deer, elk, bison and other exotic ungulates that are helping to diversify Ontario's agriculture. Besides providing nutritious low-cost feed, they allow farming to be carried out in parts of Ontario where other crops cannot be produced without depleting the soil.

First-class and even second-class pastures just don't happen. They are the result of good management – management based on the knowledge of how plants grow, their fertility requirements and their ability to withstand grazing and trampling by animals.

Pastures can be improved through a combination of weed and brush control, fertilizing, reseeding to higher-producing species, and grazing management. This publication highlights the principles and management practices for top production and utilization of pastures in Ontario.

TYPES OF PASTURES

NATURAL UNIMPROVED PASTURES

The climax vegetation of Ontario is mixed conifers and deciduous forest. Only shade-enduring grasses and those adapted to wet locations were found by early settlers. The so-called natural grasses which now inhabit pastures, roadsides and roughland in Ontario are the survivors of the grasses introduced by settlers (O. McConkey, *Pasture Survey,* 1931).

Kentucky bluegrass, Canada bluegrass and redtop are the three dominant grass species found in unimproved areas. Kentucky bluegrass grows on the better, well-drained clay loam soils while Canada bluegrass is dominant on heavy clay soils, sandy soils and shallow soils. Redtop is the dominant grass growing on poorly drained acid soils or areas with very low fertility.

While these grasses may dominate in specific areas, they are not the only plant species present (Table 1). Natural pastures are complex plant associations whose composition is influenced by the growing conditions, the weather, and the animals using the area.

TABLE 1. Occurrence and Abundance of Major Characteristic Species in Roughland Pastures

Deep Soil Pastures over 12 inches	Abundance plants / sq m	Shallow Soil Pastures under 12 inches	Abundance plants / sq m
Canada bluegrass	10	Canada bluegrass	10
Black Medic	0-1	Wild Strawberry	1-10
Golden Rod	0-1	Oxeye Daisy	0-1
Silvery Cinquefoil	0-1	Hawkweed	0-1

Source: Watkin, E.M. and J.E. Winch. Roughland pasture assessment and improvement project. Projects Nos. 25021 and 6011.

Species found in natural pastures are rarely highly productive.

Natural pastures provide good grazing in the spring but by mid- to late-June production slows to a standstill. On average, unimproved roughland pastures produce 80% of their total production by the end of June. Consequently, these pastures have a low seasonal carrying capacity.

ESTABLISHED PASTURES

Areas seeded for pastures have several advantages over natural unimproved pastures. They are higher yielding with a better distribution of that yield over a longer grazing season. Usually newly established pastures have a good legume content and therefore do not require nitrogen fertilization for good productivity.

Pastures can be established with the intention of supplying a grazing area for a short period of time or permanently. In long-term pastures the plant composition changes with time. Plant succession in pastures normally occurs as follows:

Productive grasses and legumes – > productive grasses – > unproductive grasses and broadleaf weeds.

If the pasture is under-utilized, small shrubs and trees will also invade the field.

This sequence of plant succession happens at different rates according to management and environmental affects. The net result is a loss of pasture productivity and quality and therefore a loss in animal gains.

One of the main goals of pasture management is to keep the pasture productive by preventing the succession of less productive species.

The persistency of productive pastures is dependent on:

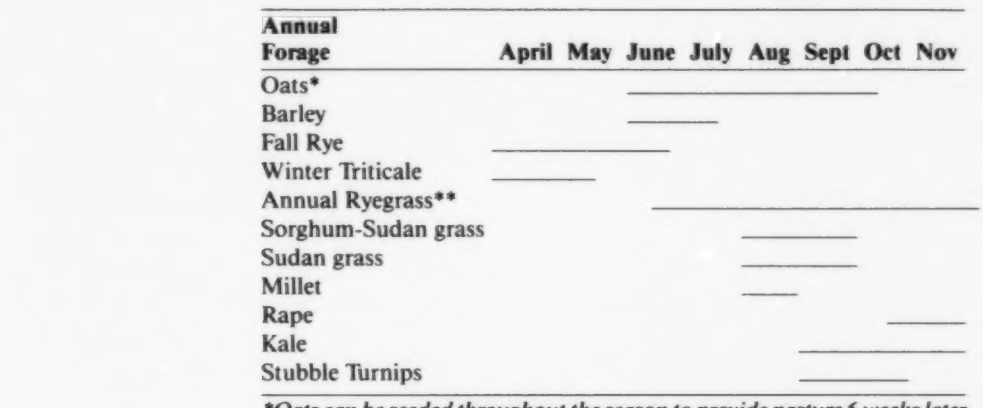
1. Selecting the right seed mixture
2. Establishing a good stand
3. Proper fertilization
4. Grazing management

IMPROVED PASTURES

Improved pastures have been reseeded, fertilized or fenced to improve productivity and utilization. This term is usually applied to rundown fields that have been renovated or rejuvenated.

ANNUAL PASTURES

Annual crops can be part of a planned pasture program or an emergency remedy in years when the regular pastures have been winterkilled or are suffering from drought. Figure 1 shows the role that annuals can play in filling in the pasture season. While annual crops offer flexibility in pasture programs, their advantages must be weighed against the cost of reseeding each year. For supplementing pastures in the summertime, consider grazing hay aftermath (second growth) or feeding hay.



**Oats can be seeded throughout the season to provide pasture 6 weeks later.*
***Production depends on adequate moisture conditions.*

Figure 1. Annual Forages Fill the Pasture Season.

PLANT SPECIES FOR PASTURES

The comments on the forage species in this publication refer only to their performance under pasture conditions. To identify species growing in an existing pasture refer to OMAF Publication 204, *Pasture Grasses Identified*, and the OMAF Factsheet, *Pasture Legumes Identified*, Agdex 130.

LEGUMES

TREFOIL

Birdsfoot trefoil has leaves composed of five small leaflets on fine stems 60 to 90 cm tall. The leaves are distinct in that they consist of two leaflets close to the stem separated from the other three by a definite stalk. Flowers are bright yellow to orange yellow and borne in clusters. Trefoil flowers from June to September. Roots consist of one deep taproot with many branching side roots near the surface. Under close grazing, or when a single trefoil plant is growing without competition, trefoil takes on a recumbent growth habit.

Trefoil is adapted to good soils but will grow on soils where marginal pH or drainage limit other legumes. It is productive from mid-June to fall and can be stockpiled for late-fall grazing. The feed quality is still good, as trefoil does not lose leaves when frosted. Trefoil can be grazed frequently if 10 cm of growth is left at all times, or grazed closely and rested for 30 to 35 days. Trefoil grazed closely during the pasture season should not be grazed during the critical fall harvest period. See OMAF Publication 296, *Field Crop Recommendations*, for more information. If trefoil is grazed during the critical fall harvest period, it should be left or just grazed lightly in the following spring.

Trefoil is an excellent legume for pastures because it does not cause bloat and can remain productive for many years. Trefoil will reseed itself if areas are left ungrazed and allowed to go to seed or rotationally grazed with 10 cm of growth left at all times.

The palatability of trefoil varies because of the presence of tannin, a bitter-tasting compound. Some strains of trefoil have low tannin levels while others have high levels. Tannin levels increase when trefoil is stressed. While the presence of tannins may adversely affect palatability, they may be responsible for enhancing animal performance such as lambing (Table 2).

TABLE 2. The Effect of Type of Legume Pasture Used During Flushing and Mating on Lamb Crop

Mixture	% lambs per ewe	% singles	% twins	% triplets
Alfalfa + grass	1.83	27	69	3
Trefoil + grass	1.92	8	74	18

Source: Leslie MacLaren. New Liskeard College of Agricultural Technology

Tannins in trefoil may be responsible for increasing the number of twins and triplets born to ewes flushed on trefoil pastures.

Trefoil seedlings are not competitive and trefoil is slow to establish. It may be thin in first-year stands but will

thicken up with time. Spring growth is also slow, but mid-summer yields are good if it is not overgrazed in the early part of the season. Trefoil can cause photosensitization in horses.

WHITE CLOVER

White clovers have stems that creep on the ground with branches that are erect or upward slanting. Leaves consist of three rounded stalkless leaflets with shiny undersides. The edges of the leaves may have a few shallow teeth. The flowers form a spherical head and are usually all white but may be pink tinged. Roots are shallow and fibrous and develop from the nodes of the creeping stems. Three types of white clover are used in Ontario. They look similar but differ in size. WILD WHITE CLOVER is the smallest ranging from 5 to 17 cm tall. INTERMEDIATE (also called COMMON, DUTCH, OR NEW ZEALAND WHITE) grows to 25 cm, while LADINO CLOVER can grow up to 60 cm.

White clover is adapted to soils that range from well drained to those with some drainage problems. Its shallow root system will limit production on excessively drained soils and in droughty periods.

White clovers will produce very palatable forage for the full season if rotationally grazed. Under continuous grazing white clover usually stops adding to pasture productivity in early to mid-July. The intermediate types tend to be more tolerant of grazing than the ladino type. White clovers are short-lived perennials that will reseed if not grazed severely. They can be frost seeded to maintain their presence in the stand. Bloat is a major concern on pastures with more than 30% white clover. It should be grown in a mixture with aggressive grasses to lower the risk of bloat. There are some reports of white clover having an oestrogenic effect on sheep.

RED CLOVER

Red clover has leaves consisting of three stalkless leaflets on tall plants (15 to 60 cm) with large rose purple to magenta flowers. Stems and leaves are hairy. Red clover has a weak taproot with many fibrous, side-branching roots. Two types of red clover are available: single cut (mammoth) and double cut (medium). Single cut is taller, coarser, later to flower and slower to regrow after grazing than double cut.

Red clover tolerates imperfect drainage and lower pH. It is productive in the first year but tends to thin out overwinter, resulting in lower yields in succeeding years. Red clover has limited use in long-term pastures because of its poor persistence. This drawback can be overcome to a certain extent by frost seeding red clover every second year. Its competitive seedlings will establish well and ensure an increase in forage. When seeded in mixtures red clover can suppress the establishment of other legumes because of its competitive nature.

Red clover can cause bloat. Pastures and hay aftermath with more than 50% red clover should be used carefully. Red clover contains compounds with an oestrogenic effect on the reproductive cycle of sheep.

ALFALFA

Alfalfa is a tall-growing plant (60 to 100 cm) with stems that can be hollow or solid. Leaves consist of three leaflets that are 2 to 3 times longer than wide with serrated tips. Flowers are usually blue or purple but may be yellow or white. Roots can be tap, branching tap, rhizomatous or creeping, but most varieties grown in Ontario have taproots.

Alfalfa requires well-drained (or tiled) soils with a pH of 6.5 or above and good fertility. Under less than ideal conditions it is susceptible to root diseases and winterkill. Alfalfa is productive for the entire growing season but should not be harvested during the critical fall period (see OMAF Publication 296).

Use of alfalfa should be limited to highly managed pastures. Grazing alfalfa before it has built root reserves, or during the critical fall harvest period, will weaken the stand. Alfalfa can be closely grazed if given a 30 to 35 day rest period to recover. Creeping-rooted alfalfas may require a 45 to 50 day rest period. In most Ontario pastures creeping-rooted alfalfas will not show the creeping behaviour.

Alfalfa plants are sensitive to physical damage from the hooves of grazing animals. To reduce the chance of the hooves slicing the crowns of alfalfa plants keep animals off the field when the ground is soft. When used in pastures, alfalfa usually does not last more than three years.

Bloat is a concern on alfalfa fields. Animals must be watered and fed dry hay before pasturing alfalfa fields to lessen the risk of bloat. As well, grazing should be delayed until the alfalfa is in flower. Alfalfa can cause photosensitization in livestock and may have an oestrogenic effect on sheep.

ALSIKE CLOVER

Alsike leaves have three stalkless leaflets with fine serrations on the edge borne on smooth slender stalks. The stems may be upright (to 50 cm) or prostrate, bearing distinctive white and rose flowers. The roots consist of a shallow branching taproot. Alsike will grow on soils that range from wet and acid to soils that are well drained and neutral.

Alsike produces most of its growth in June. Performance is not consistent from year to year and the addition of alsike to a mixture usually lowers total yield. It is not normally recommended for pastures. Alsike can cause photosensitization and other health disorders in horses as well as bloat in ruminants.

SWEETCLOVER

Sweetclover is a tall (up to 2 m), branched, coarse plant. Leaves have three oblong leaflets with serrated edges. Flowers are white or yellow and are numerous in long, loose flower arrangements called racemes. Sweetclover has a strong, deep taproot. Crushed stems and leaves have a distinctive sweet odour.

Sweetclover will grow on low fertility provided pH is near neutral or higher. Sweetclover has a very hard seed coat which must be scarified to allow even germination. Most seed of commerce is scarified prior to sale. Sweetclover

grows slowly in the first year and does not flower. In the spring of the second year it grows quickly to become a tall, coarse-stemmed plant. It can be grazed in the second year. After grazing the plant will not regrow. The yellow flowered form is more palatable to livestock. Sweetclover has limited use in pastures as it is a biennial. It can be used on land that needs the deep taproot to break up a hardpan.

Sweetclover hays, especially if mouldy, may contain dicoumoral which can prevent normal blood clotting and result in the death of livestock from internal haemorrhaging.

CROWNVETCH

Crownvetch has coarse, hollow stems that grow 30 to 150 cm long and are semi-reclining. It will not climb like a vine as no tendrils are present. Overall height is about 70 cm. Leaves are compound with 5 to 25 pairs of narrow, oblong leaflets. Whitish-pink to purplish-pink flowers are borne in a cluster at the tip of a long stalk in a crown-like arrangement. The plant has a deep tap with many side-branching roots.

Crownvetch requires well-drained, fertile soils. It is usually difficult to establish but is long lived once growing. Crownvetch requires warm temperatures before germination can take place (usually in late May or June). The young seedlings are not vigourous, making crownvetch susceptible to competition from earlier and more vigorous growing plant species. Crownvetch's deep branching root system makes it extremely stable on slopes. It is useful to stabilize steep slopes and prevent erosion. Crownvetch will not persist if overgrazed. It performs best when continuously grazed with a low stocking rate. Fall regrowth should not be grazed. Crownvetch can be used for shallow soil pastures but production is limited (Table 3).

TABLE 3. Dry Matter Yield (kg/ha) of Crownvetch on Shallow Soil Pastures

County Location	Year Seeded	Crop			
		year 1	year 2	year 3	year 4
Leeds	1969	4645	2945	2873	2580
Wentworth	1971	7022	—	—	—
Lennox & Addington	1971	5554	3460		

Yields are from one cut only

Source: Watkin, E.M. and J.E. Winch. An assessment of shallow soil pastures in Ontario. A.R.D.A. Project Report #85045

Crownvetch can be used on shallow pastures but is susceptible to overgrazing.

BLACK MEDICK, HOP CLOVER AND TUFTED VETCH

These three weeds are legumes that often appear in pastures. Like the other legumes, they provide nitrogen to surrounding grasses and have a good quality feed value. Their drawback is that their yield is extremely low.

GRASSES

ORCHARDGRASS

Orchardgrass is an aggressive, light green bunchgrass. It has long, wide leaf blades and a coarsely tufted panicle. The cross-section of the stems is oval shaped.

Orchardgrass requires well-drained soils with good surface drainage. It is normally ready for grazing by late April or early May. Grazing should start when the orchardgrass is 8 to 10 cm tall. It will remain productive for the full season if moisture conditions are good and the stand is rotationally grazed. It should be grazed heavily with an 18 to 25 day rest period in the summer. Orchardgrass should be grazed lightly in the fall to remove thick growth that could lodge and cause winterkill.

It is palatable when young but loses palatability and digestibility faster than other grasses. Late-maturing orchardgrass varieties are easier to manage than the fast-maturing earlier varieties. If left ungrazed, orchardgrass will form tough, unpalatable clumps. It responds well to high rates of nitrogen in pure stands, or can be used in mixtures with legumes. It is difficult to get trefoil or alfalfa to persist when grown with orchardgrass.

Grass tetany is a concern on early pastures dominated by orchardgrass, as the plants may not have sufficient levels of magnesium to supply animal needs.

BROMEGRASS

Smooth bromegrass is a tall grass that varies in colour from light to dark green. The leaves are long, wide and flat with a pointed tip. Brome leaves have a "W" marking on the leaf. The roots have blunt, brownish rhizomes that allow the plant to spread to form an open sod. The inflorescence is a large spreading panicle that looks similar to oats, giving rise to the older name of "oatgrass."

The deep, fibrous roots of brome allow it to adapt to well-drained or droughty soils. Because it is early, fields should be well-drained to prevent animal foot problems and forage damage during early grazing. Brome is most productive during spring and fall with mediocre to good mid-season production.

Bromegrass is best suited to rotational grazing where it can be grazed heavily in the spring, lightly in the summer and heavily again in the fall. It will tolerate continuous grazing with low stocking rates but summer productivity will be low and fall growth will be severely lowered. When rotational grazed, bromegrass should be eaten down to a height of 10 cm and allowed to recover. In the summer this usually takes 30 to 35 days. It is suitable for mixtures with trefoil where the brome is grazed early, allowing the trefoil to grow and provide pasture for the summer. Bromegrass is palatable and tends to retain its nutritional value better than most grasses, giving pasture managers more flexibility in grazing schedules.

Bromegrass has a very large, light, fluffy seed which causes difficulties when planting with many types of seeders. Once established, brome is a strong competitor which can out-compete legumes on low potash soils.

REED CANARYGRASS

Reed canarygrass is a tall (up to 2.5 m), coarse grass with rhizomatous roots that form a loose sod. It is easily distinguished by its wide leaves. The inflorescence is a panicle similar to orchardgrass but with finer tufts.

Reed canarygrass is very widely adapted. It will tolerate excessive soil moisture, including prolonged flooding or will grow on droughty soils. It will also tolerate low pH and fertility but best yields are obtained on well-drained, fertile soils. It is ready to pasture early in the season and will remain productive if kept vegetative.

Reed canarygrass has typically been seeded on wet pastures where the animals could not pasture until the grass was well past heading and producing seed. It can be the basis of a productive, drought-resistant pasture if seeded on well-drained soils where it can be pastured on a quick rotation for the full season. Reed canarygrass develops coarse stems and leaves, and loses palatability and digestibility quickly once it heads. Grazing should be timed to keep the plants vegetative (not exceeding 30 cm of growth at any time). Reed canarygrass can be used with any of the legumes but white clover is the best choice for short grazing rotations.

Reed canarygrass is slow to establish and is not aggressive in the seedling year. Older varieties of reed canarygrass contain alkaloids which depress animal performance. Current recommended varieties are free of the undesirable tryptomine and carboline alkaloids. Palatability of the new reed canarygrasses is excellent and animal performance is good.

TIMOTHY

Timothy is light green with wide, medium length (7 to 25 cm) blades. The head is a distinctive, very dense spike-like panicle. It has an onion-like bulb or corm at the base of the stems and a shallow root system. Timothy is a non-aggressive bunchgrass with limited tillering ability.

Timothy is widely adapted to heavier soils, variable drainage, fertility and pH. It is most productive in the spring, followed by lower mid-season productivity and little fall growth. The shallow root system make it very susceptible to drought and high temperatures. To maximize production, timothy should be allowed to reach the boot stage before the first grazing. For this reason, and the lack of mid-summer production, timothy is not an ideal pasture grass. It is best used in mixtures with trefoil where the first cut is harvested for stored feed and the aftermath grazed. Timothy is commonly added to pasture mixtures because it is easy to establish and acts as stand insurance.

FESCUES

CREEPING RED FESCUE

Creeping red fescue is a short plant with narrow, bristly, dark green leaves. On older leaves the basal leaf sheaths are a reddish-brown, giving the plant it's name. The roots are rhizomatous and form a dense sod. The inflorescence is a fine, open panicle.

Creeping red fescue will grow and spread on most soils including fertilized subsoils. It grows throughout the entire season and retains good nutritional value in the fall. Productivity is limited as the grass is short and most varieties have been developed for turf or soil conservation purposes.

Creeping red fescue is best used for streambank or grass waterway protection, as the roots hold the soil while the thatch of top growth slows water movement and protects the soil surface. These characteristics make it a good "bottomgrass" – a species added to a mixture to give turf qualities to the forage. As such, it should be added to mixtures for exercise yards, laneways and fields that are wet – areas where the plants tend to be damaged by animal traffic in rainy periods.

TALL FESCUE

The leaves of tall fescue are dark green and ribbed with wide, long blades and sharp-pointed tips. This deep-rooted, tall, coarse-growing plant will form tussocks after several years growth if not grazed or cut. It is basically a bunch grass but frequent grazing will produce a tough sod resistant to trampling damage.

Tall fescue is adapted to most soils including those with imperfect drainage. Spring growth is slow, followed by steady production through the summer and fall. It makes a good fall pasture as the quality of the forage is maintained provided the stand has been grazed throughout the season. It fits well into a rotational grazing system where it is grazed in late June and early July then allowed to stockpile in late summer for fall grazing. In a mixture with trefoil it will provide season-long forage.

Tall fescue is useful for erosion control and for the protection of fragile lands. Its deep roots, long-lived perennial nature and tolerance to marginal conditions allow it to establish and survive on most areas where permanent cover is required.

A seed-borne fungus (an endophyte) has been linked with poor animal performance on tall fescue pastures. Once introduced to the stand by infected seed, the fungus cannot be removed. Endophyte-free seed is available and should be used.

MEADOW FESCUE

Meadow fescue has bright green leaves with narrow, long (to 50 cm) blades and sharp-pointed tips. The leaves are dull on the upper sides and shiny on the undersides. Meadow fescue is a bunch grass with short rhizomes that give it a weakly creeping habit.

Meadow fescue grows best on deep, fertile soils but will tolerate variable drainage and low fertility. It has a shallower root system, is shorter lived and is not as tolerant of poor growing conditions as tall fescue. Meadow fescue is most productive in the summer and the fall and maintains feed quality into the cooler fall months.

It fits well with trefoil to give summer and fall grazing. This allows it to be used on fields that tend to be wet in the spring and cannot be grazed until later in the season.

MEADOW FOXTAIL

Meadow foxtail resembles timothy but has smaller, ribbed leaves. It is a shorter plant and heads out much earlier than timothy. Roots are shallow and fibrous.

Meadow foxtail tolerates poor drainage and low pH. It is extremely early, with most fields heading out by early May. Once headed out it is very unpalatable. Meadow foxtail is the earliest pasture species but is often seeded on fields that are too wet to carry animals at the time grazing

should start. The shallow roots contribute to low production during periods of high temperatures and drought. It is best used in a mixture with species that will produce through the summer.

Meadow foxtail seed is light, fluffy, and hairy, making it difficult to seed. Using coated seed avoids problems at seeding.

BLUEGRASSES

KENTUCKY BLUEGRASS is a dark green grass with long narrow leaves. Blades have a boat-shaped tip and shiny undersides. It grows 30 to 100 cm tall with an open fine panicle. Kentucky bluegrass forms a dense sod on fertile soils.

CANADA BLUEGRASS is a bluish-green grass with shorter leaves and a boat-shaped tip. The plant is shorter than Kentucky bluegrass with a similar open fine panicle. Canada bluegrass forms an open sod and is found on less fertile soils.

Both species have a dense but shallow root system that limits summer productivity where water is limited. Bluegrass grows most strongly in the spring, so it must be stockpiled for midsummer production. Early growth is palatable but total production is limited.

Bluegrass withstands animal traffic and can be added to a mixture for areas where trafficability is important or as a bottom grass in horse pastures. The dense root system and thatch make bluegrasses suitable to areas in need of erosion control. These grasses, especially Kentucky, form the dark green lawns for display paddocks.

PERENNIAL RYEGRASS

Perennial ryegrass is a soft, fine, bright green grass. The leaves are narrow and short with ribbed tops and smooth, shiny undersides. It produces a lot of tillers and is 30 to 60 cm tall with an inflorescence composed of a slender stiff spike with each spikelet edgewise on the central axis.

Perennial ryegrass requires well-drained, fertile soils. It grows quickly during periods of cool wet weather, so it is most productive in the spring and the fall. During these periods, perennial ryegrass regrows quickly, enabling frequent grazing of a highly palatable and digestible forage. It cannot tolerate hot or dry conditions and is unproductive in the summer – a major drawback for its use in pastures. It is suited to rotational grazing where other species are available for summer grazing. If used, perennial ryegrass should be part of a mixture with alfalfa or white clover.

Pure stands of perennial ryegrass may be an option if irrigation is a possibility. Ryegrass responds extremely well to nitrogen fertility and the resulting yields may warrant the cost of irrigating. Nitrogen should not be applied later than July and any fall top growth should be grazed off before winter.

Perennial ryegrass is available in varieties suited to turf, hay or pasture. The limitations to using the hay and pasture varieties are poor summer production and a lack of winter hardiness; existing varieties have insufficient winter hardiness to receive a recommendation in Ontario.

FESCUE RYEGRASS CROSSES

Breeders have been crossing tall and meadow fescues with annual and perennial ryegrasses to incorporate the benefits of both species. Each variety of these crosses must be examined individually as it may have varying amounts of the characteristics of each of its parents.

REDTOP

Redtop has dark green leaves with a purplish inflorescence that turns red as it opens. It has fine leaves and stems that are both upright and creeping. Redtop forms a loose sod.

Redtop is tolerant of low fertility, pH and poor drainage but does not yield well. It is not competitive on fertile soils and often disappears if soil conditions are improved. Productivity and feed quality are lower than timothy. Redtop can be used on ditchbanks or grass waterways where its tolerance for wet soils and sod-forming habits reduce erosion.

ANNUAL SPECIES

For a full discussion of annual forage crops, see the OMAF Factsheet, *Annual Forages For Pastures*, Agdex 133.

ANNUAL RYEGRASS

Annual ryegrasses are short, leafy, highly tillered, light green grasses. Italian types will not form a head in the seeding year so remain leafy the entire season. The Westerwolds types of annual ryegrasses are taller and will go into the reproductive growth stages in the year of seeding. The heads are similar to perennial ryegrass. Roots are very shallow and form a dense, fibrous mass about 5 cm deep.

Annual ryegrasses are adapted to areas with continuous rainfall. Dry, hot weather causes them to stop growing and in cases of severe drought they will die. Ontario production is limited to early and late season with little or no growth over the summer.

They are best used in pure stands with split applications of high levels of nitrogen to maintain growth. Protein and intake are high but fibre levels are very low.

FORAGE BRASSICAS

Forage brassicas consist of KALE, FORAGE RAPE and FORAGE TURNIPS. Seeded in the summer, they provide high-quality forage for grazing in late fall. They need to be seeded on well-drained, fertile soils. Forage brassicas should be strip grazed to prevent large losses. Hay or a permanent pasture should be available at the same time in order for the animals to have enough fibre in their diets as well as to prevent several animal disorders associated with grazing brassicas. Refer to the "Animal Health Problems Caused by Forages" section in this publication.

SORGHUM-SUDAN GRASS HYBRIDS AND SUDAN GRASS

Sorghum-sudan hybrids and sudan grass are tall growing sub-tropical annual grasses. They will head and form seeds when they reach a height of 2 m or more.

Sorghum-sudan hybrids and sudan grass require medium to well-drained soils and good fertility. They are better adapted to mechanical harvesting than animal grazing, as

losses under grazing conditions can be high. Rotational grazing makes better use of the forage and allows regrowth of previously grazed areas. Plants should not be grazed too early, during droughts, or after frosts in order to decrease the risk of prussic acid poisoning.

Horses should not be allowed to graze these plants as they may develop Cystitis (urinary tract infection). This condition looks like colic with the addition of bloody urine and can be fatal to horses.

CEREALS

Cereals are annual or winter annual grasses and will supply pasture if grazed when vegetative. Yield is low at this stage of growth but they provide forage on an emergency basis. Protein and digestibility are good but dry matter and fibre levels are low.

ESTABLISHING PASTURES

The successful establishment of a new pasture requires planning and good management. A thick vigourous stand forms the basis of a productive pasture.

SOIL TEST

The first step in establishing a new pasture is to determine the existing fertility levels and pH of the soil to be seeded. A soil test should be done the year before seeding is to be carried out. See "Fertilizing Pastures" for more discussion on soil testing.

SELECTING A SEED MIXTURE

GROWING CONDITIONS

Select a seed mixture that is adapted to the growing conditions in the field. Drainage, soil pH, natural fertility, soil depth and texture should all be taken into consideration. Plant only grasses and legumes that suit the growing conditions found in the field. The information in this publication and in OMAF Publication 296, *Field Crop Recommendations*, can help in the decision making process.

Consider how "early" the area to be seeded is in most years. Fields that dry up quickly and are accessible early in the pasture season are ideal for mixtures with orchardgrass or meadow foxtail. Both of these fast-starting grasses can advance the normal grazing season, but become unpalatable and of poor feed quality if allowed to mature. The animals must have access to them, once they are ready to be grazed. Reed canarygrass-based mixtures are also ideal for early land. A trefoil-based mixture with a grass such as brome or timothy is suitable for fields that are slow to dry.

PURPOSE OF THE MIXTURE

The species in the mixture and the proportion of each species depends on the use of the mixture: hay-pasture, permanent pasture, or exercise area. Species such as bromegrass, timothy, orchardgrass, tall fescue, alfalfa, and trefoil provide good hay yields as well as pasture. Shorter growing species, such as the bluegrasses, creeping red fescue, redtop and white clover are not suitable for hay but are useful in pastures or exercise paddocks.

COMPOSITION OF THE MIXTURE

Legume-grass mixtures are preferred for seeding pastures because they produce higher animal gains and milk production, do not require nitrogen fertilizer to yield well and perform better during hot, dry weather.

The legume component in the mixture improves the nutritional value of the pasture. The feed quality of legumes is superior to that of grasses and does not decline as rapidly with age. In addition, grasses grown with legumes usually contain a higher percentage of crude protein than grasses grown in pure stands. The stimulating affect on the grass is caused by the release of nitrogen compounds from legume roots and root nodules. Bacteria living symbiotically in the root nodules use nitrogen from the air for their growth and development. While most of the "fixed" nitrogen is available to the legume, some is excreted into the soil where it becomes available to the grasses. When the bacteria die and the nodules decompose, additional nitrogen becomes available to the grasses. Ladino and intermediate white clovers supply relatively high amounts of nitrogen to companion grasses while alfalfa, birdsfoot trefoil and red clover supply smaller amounts. Nitrogen fixation allows legume-grass mixtures to yield well without the addition of nitrogen fertilizer. Phosphorus and potassium plant nutrition levels in the soil must be maintained to ensure balanced growth of the legume and grass components.

Legumes generally have deeper root systems than grasses. This allows access to deeper soil moisture and in turn, legumes yield better in the summer. This produces a more steady production of forage over the grazing season. Overgrazing, which damages root systems, destroys the advantage of having a good legume population in a pasture. Grasses grown with legumes reduce the danger of bloat, increase the possibilities of having a thick pasture without weeds, and help to reduce winterkilling of legumes. If legumes winterkill, the grasses can be fertilized with nitrogen to provide pasture for the season. Legume-grass mixtures are successful because there is a natural, close association due to differences in nutritive requirements and root systems. Complementary grasses and legumes make the best use of climatic, soil and growing conditions.

The success of a forage mixture depends on the correct selection of the legume and grass components. Both must suit the conditions under which the mixture is grown.

TYPES OF MIXTURES

Complex Mixtures

Early- and late-maturing species and varieties are often combined in complex mixtures in an attempt to produce a long and uniform supply of pasture over the season. These mixtures are based on the idea that different species and varieties come into peak production at different times in the season. Ideally this one mixture would supply pasture for the entire grazing season. The yielding ability of mixtures and the distribution of that yield is associated with the species in the mixture rather than the complexity of it (Table 4). **It is important that mixtures be made up of compatible legumes and grasses.** As the number of species in a mixture increases, the opportunity for unbalanced competition among them also increases.

TABLE 4. Comparison of Red Clover Hay-Pasture Mixture Yields

Mixture	June Hay	Aftermath Production	Total Yield	% Increase Over Red Clover + Timothy
	lb/acre			
Red clover + timothy	5240	1200	6440	0
Red clover + alfalfa + timothy	5480	2260	7740	20
Red clover + alfalfa + timothy + orchardgrass	4740	2360	7100	10
Red clover + alfalfa + timothy + bromegrass	5560	2380	7940	24
Red clover + alfalfa + ladino clover + timothy + orchardgrass	5180	2600	7780	21
Red clover + alfalfa + ladino clover + timothy + bromegrass	5520	2280	7800	21
Red clover + alfalfa + ladino clover + timothy + orchardgrass + bromegrass	5020	2540	7560	17

Source: R.S. Fulkerson: Research Review of Forage Production. Ontario Agricultural College, University of Guelph. 1983.

It is the right combination of grasses and legumes that makes the difference – not the number of species in a mixture.

Simple Mixtures

Simple mixtures contain one legume with one or two compatible grasses. They are easier to manage than complex mixtures for high yields and give a more even rate of gain or milk production throughout the season. Two or three simple mixtures planted in different fields can ensure a steady production of forage.

Complex Versus Simple Mixtures

Management practices and environmental conditions influence the competitive abilities of each species differently. Simple mixtures are easier to manage for high yields and should always be used when pasture management is intensive. It is not possible to manage a complex mixture for maximum production of one species without creating conditions which will harm another species. Yield from the species less adapted to the management will decrease and eventually the species will disappear as the plants die. Complex mixtures may be appropriate when the field is variable, and a lower carrying capacity is sufficient. **No matter what type of mixture is being used, seed mixtures for pastures should have grasses and legumes with similar maturities. Use of different maturities encourages the overgrazing of the younger, late-maturing species and undergrazing of the faster maturing plants.**

Forage Species	Frequent, Close Grazing	Rotational Grazing	Stored Feed
Alfalfa	□	●	■
Birdsfoot trefoil	□	■	■
Red clover	□	●	■
White clover	■	■	●
Alsike clover	□	●	●
Sweetclover	□	●	●
Bromegrass	□	●	■
Timothy	□	●	■
Reed canarygrass	□	■	■
Orchardgrass	■	■	■
Perennial ryegrass	■	■	■
Annual ryegrass	■	■	■
Tall fescue	□	●	■
Meadow fescue	□	●	■
Creeping red fescue	■	■	□
Meadow foxtail	□	●	□
Kentucky bluegrass	■	■	□

■ *Highly suitable*
● *Suitable*
□ *Not recommended*

Figure 2. Suitability of forage species to different types of harvest management.

TYPE OF GRAZING MANAGEMENT

The grass and legume species have different tolerances to being grazed. Some, like Kentucky bluegrass, can survive frequent close grazing, while others survive only if grazing is infrequent (Figure 2). Select a mixture where all the species fit the grazing management.

TABLE 5. Suggestions For Pasture Mixtures

Soil Drainage	Short-Term Pastures 3 to 4 Years		Long-Term Pastures 5 Years or More	
	Components	Seeding Rate kg/ha	Components	Seeding Rate kg/ha
Well-Drained	Alfalfa	11	Trefoil	9
	Orchardgrass	6	Timothy	2
	Alfalfa	9	Trefoil	9
	Ladino	2	Bromegrass	4
	Timothy	4		
	Bromegrass	9	Trefoil	9
			Meadow Foxtail	10

TABLE 5. Suggestions For Pasture Mixtures
(continued)

Soil Drainage	Short-Term Pastures 3 to 4 Years		Long-Term Pastures 5 Years or More	
	Components	Seeding Rate kg / ha	Components	Seeding Rate kg / ha
Well-Drained	Alfalfa	9		
	Ladino	2	Trefoil	8
	Orchardgrass	3	Tall Fescue	10
	Bromegrass	9		
			Trefoil	8
	Alfalfa	9	Creeping Red	
	Ladino	2	Fescue	6
	Orchardgrass	2		
			Trefoil	8
	Alfalfa	11	Orchardgrass	4
	Bromegrass	9		
			Trefoil	9
	Alfalfa	9	Reed Canary	
	Ladino	2	Grass	7
	Bromegrass	4		
			Reed Canary	
	Alfalfa	6	Grass	9
	White Clover	2	White Clover	2
	Timothy	2		
	Bromegrass	4	Trefoil	9
	Meadow Fescue	3	Ladino	2
			Timothy	4
	Orchardgrass	9		
	White Clover	2		
Moderately Well-Drained	Alfalfa	9	Trefoil	9
	Ladino	2	Timothy	2
	Timothy	4		
			Trefoil	9
	Alfalfa	9	Bromegrass	4
	Ladino	2		
	Reed Canary	8	Trefoil	9
			Meadow Foxtail	10
	Alfalfa	9		
	Ladino	2	Trefoil	8
	Meadow Foxtail	10	Tall Fescue	10
	Red Clover	4	Trefoil	8
	Ladino	2	Creeping Red	
	Timothy	8	Fescue	6
	Orchardgrass	9	Trefoil	8
	White Clover	2	Orchardgrass	4
			Trefoil	9
			Reed Canary	
			Grass	7
			Reed Canary	
			Grass	9
			White Clover	2
Fair To Poorly Drained	White Clover	2	Trefoil	9
	Timothy	6	Timothy	2
			Trefoil	9
			Bromegrass	4
	Red Clover	6	Trefoil	8
	Alsike	3	Creeping Red	
	Timothy	8	Fescue	6
	Red Clover	4	Trefoil	6
	White Clover	2	Timothy	2
	Timothy	8	Brome	5
			Tall Fescue	5

TABLE 5B. Suggestions for Horse Exercise Paddocks

Soil Drainage	Components	Seeding Rate kg / ha
Well-Drained	Tall Fescue	6
	Kentucky Bluegrass	10
	White Clover	2
Moderately Well-Drained	Tall Fescue	10
	White Clover	2
	Timothy	5
	Kentucky Bluegrass	8
	White Clover	2
	Timothy	2
	Creeping Red Fescue	6
	Kentucky Blue	3
	White Clover	2

SEEDING RATES

Use the rates found in this publication or in OMAF Publication 296, *Field Crop Recommendations.* These seeding rates have been found to produce good stands on average to good growing conditions. Higher seeding rates do not as a rule give greater yields (Table 6). Higher seeding rates are only useful in very poor seeding conditions when high seedling mortality is expected.

TABLE 6. The Effect of Seeding Rates on Yields

Mixture	Seeding Rate lb / Acre	Dry Matter Yields Tons / Acre 5 Year Average
Complex		
- meadow fescue, Canadian brome, ryegrass, timothy, domestic ryegrass, red fescue, ladino clover, white Dutch clover, Lincoln brome, wild white clover, redtop, Wood's meadow grass, Kentucky blue, wheat	12	2.15
	20	2.10
	35	2.12
		Average 2.12
Less Complex		
- ladino clover, red clover, alsike clover, timothy, orchardgrass	12	1.84
	20	1.92
	35	1.79
		Average 1.85
Simple	12	3.26
- reed canary, birdsfoot trefoil	20	3.34
	35	3.43
		Average 3.34

Source: Dr. John B. Washko, Department of Agronomy, The Pennsylvania State University

High seeding rates do not always produce better yields.

SEED QUALITY

Good quality seed should always be used when establishing a pasture. Use of certified seed ensures germination, good seedling vigour and the introduction of fewer weed seeds. Certified seed is your guarantee of quality.

Select forage varieties recommended by OMAF Publication 296, *Field Crop Recommendations.* These varieties have proven themselves in performance trials to be adapted to Ontario conditions.

DIRECT VERSUS COMPANION SEEDING

Most pasture seedings should be made without a companion crop. The companion crop competes heavily with the establishing forages for light, moisture and nutrients. If a companion crop is needed for erosion or weed control, or required for feed or straw, the following points will help ensure a good forage establishment:

- Use oats seeded at a light rate – less than 60 kg / ha (1 ½ bushel / acre).
- Use an upright oat variety with low tillering ability.
- Harvest the companion crop as silage at the late boot stage or by grazing when it reaches 30 cm in height.
- Avoid using high nitrogen fertilizers, or heavy rates of manure which tend to result in lodging.
- Remove badly lodged companion crops as soon as possible after lodging.

LEGUME INOCULATION

Inoculation refers to mixing rhizobium bacteria with legume seeds prior to planting. After germination, the bacteria invade the root hairs of the young seedlings, nodules are formed and the legumes "fix" nitrogen from the air. Well-nodulated legumes get enough nitrogen through fixation to yield well without nitrogen fertilizer. Each legume species requires a specific strain of rhizobium for nodule formation. Pre-inoculated seed is available or inoculation can easily be done at the farm. When buying the inoculant separately, check for the expiry date and handling cautions on the package to ensure effective nitrogen fixation. Legumes should be inoculated just before seeding. Inoculated seed should not be mixed with fertilizer.

THE SEEDBED

The most important step in establishing forages is seedbed preparation. A good seedbed is essential for good establishment. The seedbed should be fine, firm and free of weeds. This allows uniform, shallow placement of the seed and even coverage to give good seed to soil contact.

DEPTH OF SEEDING

Forage seeds should be planted close to the soil surface as forage seeds are small and have little energy reserves to grow a shoot to the soil surface. Seeds should be placed less than 1 cm deep. Seeding too deep is one of the major causes of establishment failure (Table 7).

TABLE 7. Influence of Seed Depth Placement on Seedling Emergence

	Percentage of Seedling Emergence			
Depth (inches)	**1/2"**	**1"**	**1 1/2"**	**2"**
Alfalfa	64	53	45	19
Red clover	56	62	22	14
Timothy	89	81	39	12
Bromegrass	78	69	51	24

Source: Bob Fulkerson, Ontario Agricultural College, University of Guelph

Planting forage seeds too deep is one of the main causes of establishment failure.

TIME OF SEEDING

Pastures should be seeded in early spring as cool moist weather is conducive to good establishment. Late spring seedings generally do not establish well. The shallowly placed seeds are vulnerable to dry conditions and one or two warm days can dry the surface soil to the point where seed germination will be stopped. Young plants with small root systems are stressed by hot, dry summer conditions and may die.

Most forages can be seeded in the first two weeks of August and still develop well enough to survive the winter; slow-establishing birdsfoot trefoil, crownvetch, and reed canarygrass are exceptions. August seedings should only be carried out in years when soil moisture conditions are good.

SEEDING TECHNIQUES

CULTIPACKER SEEDER

A cultipacker seeder has two corrugated rollers with the seed box mounted between the rollers. The first roller makes a groove into which the seed is dropped. The second roller covers the seed by packing soil around it. Cultipacker seeders cannot apply fertilizer. It should be broadcast prior to seeding.

GRAIN DRILL AND BAND SEEDING

A drill with a forage seed box can be used quite successfully for seeding forages. Band seeding is a technique which assures correct placement of both seed and fertilizer (Figure 3). The fertilizer is banded in the soil by the coulters, the seed is dropped on the soil surface 15 to 25 cm behind the fertilizer and the seed is covered by drag chains or a cultipacker.

Most commercial seed drills may be adapted to carry out band placement. The seed is carried to within 7 to 10 cm of the soil surface by extended plastic or metal tubes. On some drills, the grass seed box may be remounted on the back of the drill to shorten the length of the seed tubes. The tubes may be rigidly fastened to the furrow opener to drop the seed 10 to 12 cm behind the furrow opener. Feeding the seed tube through short pieces of pipe attached to the footboard is preferred. The tube is subject to less vibration, hence less scattering of the seed, than when attached to the furrow opener. Reduction of the tractor speed to 6 km

per hour or less reduces vibration, places the seed over the fertilizer, and improves uniformity of seed placement depth.

Shallow covering of the seed can be accomplished by drag chains, a chain harrow, or cultipacker pulled behind the drill, or preferably by a small, 6 cm wide packing wheel rolling behind each furrow opener. Where packing wheels are used, less compaction of the soil surface occurs than with field rollers or other packing machinery. Erosion problems are reduced while germination and emergence is more rapid and uniform.

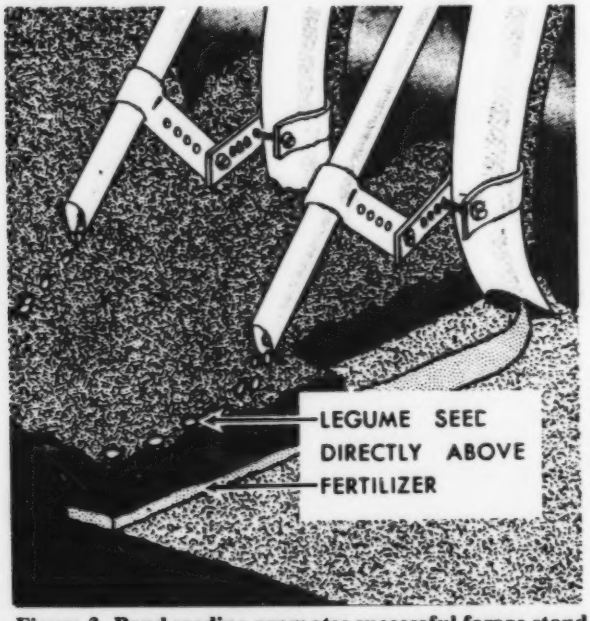


Figure 3. Band seeding promotes successful forage stand establishment.

Plant nutrients are essential for seedling development and growth. The primary nutrient required is phosphorus, as it stimulates early root and shoot development. Small-seeded forages need a large, readily available source of phosphorus after germination and benefit from phosphorus banded below the seed. Where adverse weather conditions are experienced during the establishment period, the readily available source of phosphorus becomes critical. Use the rate of phosphorus indicated by the soil test results. If your soil tests very high in phosphorus, it may not be economical from a yield increase standpoint to band phosphate.

WEED CONTROL WHEN SEEDING FORAGE STANDS

Weeds hinder the establishment of a productive pasture. Fast-growing weeds can crowd out or smother young forage seedlings. Many weed seeds remain viable in the soil for over 20 years, making it impossible to have a perfectly weed-free seedbed. Prevent as many weeds from becoming established as possible.

Control weeds such as quackgrass and dandelions with cultural or chemical methods prior to seeding. Use certified seed to prevent seeding hard-to-control weeds and fertilize to encourage good forage growth. Chemical weed control can be used to a limited extent. Because pasture mixtures are usually composed of grasses and legumes, there are very few herbicides that are safe to use on both types of plants and also effective against weeds. Check OMAF Publication 75, *Guide to Weed Control*, for herbicide information. If weeds become a problem, clipping can be an effective control measure. Clip the weeds before they set seed. It may be necessary to clip several times if the weeds have large root reserves to support new growth.

PASTURE IMPROVEMENT

Pastures that are no longer productive can be improved without ploughing. There are two basic approaches to restoring established pastures to a productive state: rejuvenation and renovation

REJUVENATION

Pasture rejuvenation involves using a fertilizer program and controlled grazing to encourage productive forage species to return and dominate a pasture. This approach recognizes that the soils that pastures are grown on are often deficient in the nutrients required to support the growth of productive plants. The three major elements, nitrogen, phosphorus, and potassium, must be present in sufficient quantity to meet the needs of desirable legumes and grasses.

Taking a soil test to determine the nutritional state of the soil is the first step in rejuvenating a pasture. Phosphorus and potassium should be applied according to the results of the soil test. Extra amounts of phosphorus and potassium have little additional affect on yield (Table 8). While the application of phosphorus and potassium can increase the amount of forage produced, it is the application of nitrogen that brings about the largest changes. Nitrogen kills moss, depresses the growth of poor-producing grasses and stimulates the growth of productive grasses. The minimum amount of nitrogen needed for rejuvenation is 75 kg per hectare. Nitrogen cannot be effective if either phosphorus or potassium are lacking.

TABLE 8. Response of Non-Renovated Pastures to Annual Applications of Phosphorus and Potassium

Site	Annual Rate of Fertilizer Application			
	O	L	M	H
	Pounds of Dry Matter Produced per Acre 3 year average			
36	309	593	676	621
38	618	949	960	1098
40	1446	1736	1753	1858
46	1385	1383	1699	2042

O = no fertilizer, L = 1/2 the recommended rate, M = recommended rate, H = 2 × the recommended rate
Source: Watkin, E.M. and J.E. Winch. Assessment and improvement of roughland pasture in Ontario. A.R.D.A. Projects 25021 and 6011. 1970.

Extra phosphorus and potassium do not always produce higher yields.

The improvement in fertility conditions can encourage viable seeds in the soil to break dormancy. Because of this unexpected grass, legume or weed species may appear in the stand.

Rejuvenation is a quick method for increasing pasture productivity. It works best on areas that have a history of being under-fertilized and undergrazed. Such areas usually contain a small number of productive grasses and legumes among the larger population of native grasses and weeds. Rejuvenation does not work as well if fields have been severely overgrazed, as the plants do not have enough roots to use the fertilizer.

Once a field has been rejuvenated, grazing management should be carried out to protect the desirable species and to discourage the poor grasses and weeds. A good fertility program must also be followed every year or the treated area will revert to its previous unproductive state.

RENOVATION

Pasture productivity can be greatly enhanced by introducing high-yielding forage species. Renovation techniques make this possible without ploughing. The success of the renovation is dependent on:

1. Selection of forage species that are adapted to the growing conditions of the field, the intended method of renovation and future pasture management.
2. Preparation of the field to be renovated.
3. Seeding at an appropriate time of the year.
4. Inoculating the legumes properly.
5. Moisture conditions at and following seeding.
6. Soil fertility at and following seeding.
7. Control of competition from the existing plants.

The established plants have all the advantages in renovated pastures. The new seedlings must be able to survive the competition with the old plants for light, moisture, space and soil nutrients. The growth of legume seedlings is severely affected by shading. It reduces their root growth more than their top growth and inhibits nodulation and nitrogen fixation. The existing grasses are superior competitors for the available soil nitrogen and the new seedlings may suffer from a nitrogen deficiency. Legume growth and nitrogen fixation are also limited on soils with low levels of phosphorus. Nutrient deficiencies must be corrected with fertilizer.

The new seedlings are vulnerable to water stress because of their small root system. Old plants with larger roots are able to access a larger soil area for available moisture. Renovating in early spring is usually the best time of year because of the higher chances of having good moisture conditions. One drawback to early spring seedings is that soil under a sod stays cooler for a longer period of time than bare soil. Low soil temperatures during germination and establishment can reduce plant density, nodulation and nitrogen fixation, and seedling growth rates. Early August renovations avoid this problem and can be successful if moisture conditions are good and there are no early killing frosts.

SEEDING INTO THE SOD

Sod seeding has several advantages over conventional seeding. Reseeding can be done in areas not suitable for ploughing, with a minimum loss of time and pasture production. As most of the soil surface remains undisturbed, few annual weeds germinate and moisture loss from the ground is kept to a minimum.

Modified grain drills or specially designed sod seeders can be used to place seed into the soil of an existing sod. This method of renovation has the highest chance of success as the seed can be placed at the proper depth in close contact with soil particles. The seed can then readily absorb soil moisture for germination.

Use of a modified grain drill is limited to areas with a thin sod and soft ground. The drill should be modified by rerouting the seed tubes of the legume seed box so that the seed falls into the grain tubes. The disks must be adjusted to place the seed and the fertilizer 0.5 - 1.5 cm deep.

Sod seeders, which were designed for the job of seeding into sod, normally do a better job of establishing new stands than modified grain drills. The various models of sod seeders available are built to handle different sod conditions, different degrees of stoniness and roughness of terrain. Before renting or buying a sod seeder check that it will be able to handle the conditions presented by the field to be renovated.

The type of groove opener on the sod seeder influences the chances of a successful establishment. There are three basic slot shapes: the "V", the "U", and an inverted "T". The seedling emergence from the "V" shape slot created by double disc openers and the torn or shattered "U" shape groove made by hoe openers is improved by press wheels operating directly on the seeds at the base of the grooves before covering. This brings the seeds into good contact with the soil. It is important that the grooves be closed in order to prevent the slot from drying out. A chisel opener creates an inverted "T" slot in the soil. In dry conditions this slot design is considered to be superior to the other two. Under good moisture conditions few differences in seedling emergence are seen. Closure of the "T" groove is improved by using either a bar harrow behind the drill or press wheels.

Prior to Renovating:

1. Cut or graze the area heavily to weaken existing plants.
2. Control problem weeds.
3. Spray the area with glyphosate in the fall prior to a spring seeding.
4. Take soil tests to determine fertilizer requirements.

At Establishment:

1. Apply a herbicide to kill or suppress the sod when grass growth reaches 5 to 10 cm - if glyphosate was not used the previous fall.
2. Inoculate legume seeds just before seeding.

3. Seed as early as possible in the spring. Make sure the seed is placed at the right depth. If conditions are dry, plant closer to 1.5 cm than .5 cm.
4. Avoid seeding when the ground is wet. This causes smearing of the slot sides leading to impeded drainage. The soil at seeding should be moist and friable.
5. Fertilize according to need.

During the Establishment Year:

1. Control competition from the old sod. Keep the old sod grazed down to allow the new plants to become established. Graze the old plants when they reach 8 to 10 cm in height.
2. Use controlled grazing management such as rotational grazing to encourage and protect the new seeding.
3. Fertilize in the fall according to soil test recommendations.

BROADCAST SEEDING

Applying seed on the soil surface of an old pasture is an easy and inexpensive method to reintroduce productive grasses and legumes. This approach makes it possible to improve almost any pasture regardless of the topography or stoniness. It works best on thin sods with bare ground showing and is more successful on fields that have been heavily grazed prior to seeding.

Broadcast seeding is more risky than seeding into the sod for several reasons.

Oversown seeds often have difficulty germinating. The conditions encountered by seed broadcast on top of the soil are more severe than those experienced by buried seed. Moisture conditions and humidity levels change quickly at the soil surface and this rapidly fluctuating environment makes for poor germinating conditions. It is not unusual for less than 75% of oversown seed to germinate.

The roots of oversown seeds can have difficulty in penetrating the soil surface (Figure 4) and growing fast enough to keep up with a retreating moisture front in the soil if conditions are dry. The primary danger is that the tips of the developing roots will be killed. The root tips, the sites at which roots grow, can quickly become desiccated. The roots must become established in order for the plant to be able to absorb water and nutrients and be anchored to the ground.

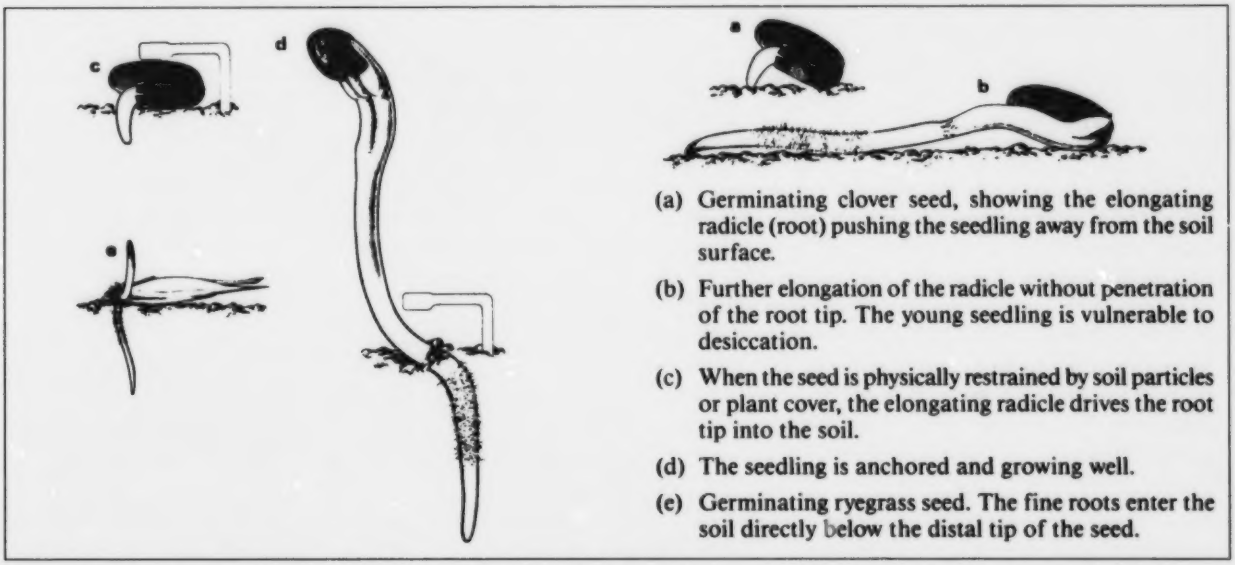
As with the other renovation techniques the seedlings are vulnerable to competition from the older plants already established in the pasture. Competition from the existing plants must be controlled by grazing or clipping.

LIMITED TILLAGE

Limited tillage can be carried out on thick sods to improve the chances of a successful broadcast seeding. The sod should be disced or harrowed so that up to 50% of the sod is killed and bare ground exposed. Annual weeds become a problem as the previously buried weed seeds germinate. The success of this method depends on the control of the existing plants and the new weed population.

FROST SEEDING

Broadcast seeding when the ground is frozen or subject to frosts is known as "frost seeding". Frost seeding can be carried out from November through to early April and, like broadcast seeding at other times of the year, works best on thin sods. The advantage of frost seeding is that the seed is worked into the ground by the freezing and thawing action of the soil. This protects it from poor moisture conditions better than seed broadcast at other times of the year. Melting snow and early spring rains also ensure there is sufficient moisture for germination. The principal dangers to the new seedlings are a late frost and competition from the established plants.



(a) Germinating clover seed, showing the elongating radicle (root) pushing the seedling away from the soil surface.

(b) Further elongation of the radicle without penetration of the root tip. The young seedling is vulnerable to desiccation.

(c) When the seed is physically restrained by soil particles or plant cover, the elongating radicle drives the root tip into the soil.

(d) The seedling is anchored and growing well.

(e) Germinating ryegrass seed. The fine roots enter the soil directly below the distal tip of the seed.

Figure 4. Germination of grass and clover seeds on the soil surface. Legume seedlings have a harder time getting their roots to penetrate the soil surface.

Source: Dowling, P.M. Establishment and survival of pasture species from seeds sown on the soil surface. Aust. J. Agric. Res. 1971, Vol. 22. 61-74.

Frost seeding can be done on top of the snow. In fact, the pattern of sown seed on the snow makes it easier to keep track of which areas have been seeded. The seed does not run off with melt water and even steep hills can be seeded using this method.

Frost seeding is more suitable for the introduction of legumes than grasses. It works particularly well with birdsfoot trefoil and the clovers. The legumes should be inoculated before seeding takes place. Seeding can be done with a cyclone seeder carried on foot or from the back of a snowmobile or all-terrain vehicle.

The "hard seed" content in seed lots of legumes usually means that the legume population will thicken up with time (Table 9). Good populations of birdsfoot trefoil are often not seen until the second year following the seeding.

TABLE 9. Average Dry Matter Yield in Kilograms per Hectare From 20 Ontario Sites Renovated With Birdsfoot Trefoil Compared With Unimproved Pastures

	Years After Renovation					
	1	2	3	4	5	6
Renovated	4600	4370	4200	4930	5180	6520
Unimproved	1240	1160	810	1300	1720	1460

Source: Jack Winch. Ontario Agricultural College, University of Guelph.

Birdsfoot trefoil plant populations build with time and this is reflected in yields.

Potash and potassium should be applied according to soil test by mid-May. In addition, the pasture should be grazed to reduce competition from the established sod.

USING LIVESTOCK TO RENOVATE PASTURES

Animals can be used to introduce legumes into pastures. These inexpensive renovation techniques are a way of improving pastures over a three- to four-year period. These methods work because the "hard seeds" found in legume seed lots are able to pass through the animal's digestive tract and remain viable. Quick germinating seeds are killed (Table 10).

TABLE 10. Effect on Germination of Type of Trefoil Seed Fed to Animals

State of Seed in the Manure	Type of Seed Eaten	
	Quick Germinating	Hard
Germinated	1.2%	8.3%
Dead	98.8%	3.3%
Hard	—	88.4%
Percentage of Live Seed	1.2%	96.7%

Source: Winch, J. Investigations into the Renovation of Roughland Areas. Ontario Agricultural College, University of Guelph. 1960.

The "hard" seeds of legumes survive the trip through a ruminant's digestive tract and can reseed a pasture.

It takes 24 to 72 hours for the seed to travel through the digestive tract. The seed will not germinate in freshly excreted faeces. The faeces must break down first and be thinly distributed on the soil.

ISLAND(S)

Legumes are established in a small area or areas and the animals are allowed to graze only after seed has set. In the process of grazing the seed is taken in and excreted in some other part of the field. The "islands" should be established at a distance from the water, salt and mineral supply.

FEEDING SEED

Legume seeds can be added to any grain being fed or to loose mineral mixes. Mature hay (containing seed) can be used as an alternative but the amount of seed ingested is relatively small.

MANURE

When manure is spread on old pastures the addition of 0.5 kilograms of legume seed to each load will eventually result in legume establishment.

CHOOSING THE IMPROVEMENT TECHNIQUE

The first step in determining which approach should be taken to improve a field is to assess why the pasture is performing poorly. Look for:

- Signs of poor fertility
- Overgrazing or undergrazing
- Weeds
- The amount and distribution of productive forages
- The amount of unproductive grasses
- Bare spots
- Thinness or thickness of the sod

If productivity is poor because of the first three signs, rejuvenation is a suitable option. If the sod is thin or full of bare patches, with little in the way of productive grasses or legumes, renovating would be a better choice.

The second step is to determine production goals for the field and how quickly the pasture must be improved. In general, rejuvenation is quicker than renovating and broadcast and sod seeding are faster than improvement methods using livestock. Legume content tends to be superior in renovated fields. These fields require less fertilizer inputs to yield well and perform better over the entire grazing season than rejuvenated fields.

The third step is to determine if there are conditions that limit the choice of any of the options. Consider:

- topography
- stoniness
- drainage conditions
- accessibility of field to equipment
- availability of equipment
- erosion potential

The final step is to consider the cost of the different improvement techniques.

FERTILIZING PASTURES

In order to grow and remain productive plants require a continuous supply of water, sunlight and nutrients. Fast growing, productive pastures have high demands for mineral nutrition.

The mineral elements that are needed by plants are classified as macronutrients (those required in relatively large amounts) and micronutrients (those needed in smaller amounts). The macronutrients are nitrogen, phosphorus (phosphate) and potassium (potash). The ten micronutrients are calcium, magnesium, sulphur, boron, chlorine, copper, iron, manganese, molybdenum and zinc. Nutrients are supplied to plants from the soil. If the soil does not contain the proper amount and balance of elements they can be obtained from manure, fixed from the air by legumes (nitrogen only) or applied as commercial fertilizers. All elements applied to the soil enter the nutrient cycle and may eventually become available to the plants. **Plants must have a healthy root system to be able to use the available soil nutrients. Overgrazed plants with small, weak root systems cannot take advantage of improvements in soil fertility.**

NITROGEN

The growth of most pastures is limited more by the lack of nitrogen than that of any other essential element. Nitrogen is a major constituent of plant proteins so is necessary for plant growth and metabolism. Plants lacking nitrogen are slow growing, small and light green in colour. Pastures that are nitrogen deficient are unproductive, slow to recover after being grazed and offer a poorer quality feed to grazing animals. The ideal supply of nitrogen to a pasture is from the fixation of nitrogen in the air by bacteria living in nodules on the roots of legumes. This source of nitrogen is continuous throughout the growing season, provides all the nitrogen required by the legumes and some for the grasses, leaves overwintering nitrogen in a non-leachable organic form and is low priced. Pastures with a legume content greater than 50% require NO additional nitrogen for good yields. A small amount (25 kg/ha) of nitrogen can be used on legume-grass pastures in the spring in order to get the grass off to a fast start and provide early grazing.

As the grass content in a pasture increases, the requirement for added nitrogen increases. To produce the same amount of forage from a predominantly grass sward as from a legume-grass pasture requires the addition of nitrogen in a readily available form — manure or commercial fertilizer.

High yields from grass pastures are obtained more efficiently by using several small applications of nitrogen rather than one large one. Frequent applications also produce a more uniform distribution of yield over the grazing season. Even in seasons with a dry period, production is better when nitrogen is applied two or three times rather than in one large application. Nitrate poisoning is a potential hazard when grasses receive nitrogen prior to a period of poor growth and precautions should be taken.

The minimum amount of nitrogen needed to produce a yield response is 50 kg per hectare. Individual applications on pastures should not exceed 75 kg per hectare. Above this rate the chances of nitrate poisoning can be high, particularly if the application is made in the summer or fall.

Fast-growing plants make the best use of applied nitrogen. Demand for nitrogen is highest in the spring and immediately after grazing. Nitrogen should be applied within one week of grazing. In rotations with short rest periods (less than 30 days), smaller nitrogen applications should be used, as the grass does not have enough time to efficiently make use of large amounts of nitrogen.

Manure can be used on pastures. Its effectiveness is dependent on when it is applied, the application rate and the uniformity of the application. It should be applied when plants are small and ready to grow quickly. Early spring is the best time of the year but fall is usually most convenient. It should be spread thinly, as clumps of manure, like manure pads, will smother small plants or shoots. An application during the growing season may cause the animals to refuse to graze the treated area. When manure is applied it is necessary to treat the whole pasture to prevent select grazing. Over-application of manure, as with other sources of nitrogen, can cause nitrate poisoning or grass tetany.

PHOSPHORUS

Plants require phosphorus to support new growth and good root development. Plant requirements for phosphorus are highest during seedling development and initiation of growth. Established plants with phosphorus deficiency will show purpling of the upper leaves. This is often seen in grasses in early spring. The cool, wet soil retards root growth and the plant is incapable of extracting sufficient phosphorus from the soil. The leaves turn purple along the margins and tips. Deficiency symptoms at this time may be more indicative of climatic conditions than an actual deficiency in the soil. A annual application of phosphorus to an established pasture is an efficient method of overcoming a phosphorus deficiency. It should be supplied in an inorganic form as commercial fertilizer or from slow-releasing ground rock phosphate. Manure is not a good source of phosphorus. Grasses are unable to make use of added phosphorus unless there is an adequate supply of nitrogen.

Seedlings that are deficient in phosphorus may exhibit a purple colour on new growth. Leaves fail to expand and the seedlings are not competitive. This can allow other species to dominate the sward at the expense of the planted species. For this reason, it is important to ensure the presence of sufficient phosphorus in the soil prior to establishing a new pasture or when renovating a pasture. Best results are obtained when the phosphorus is incorporated at the time of seeding, as phosphorus moves slowly in the soil. Banding phosphorus gives the small plants ready access to a good supply of this essential nutrient.

Most Ontario soils are low in phosphorus. Improving soil phosphorus levels results in better plant growth, increased palatability, feed intake and digestibility.

POTASSIUM

Potassium is referred to as the regulating element in plants. It is essential for plant growth and reproduction. The major symptoms of plants grown on low potassium soils are slower growth and reduced root reserves. On pastures, this results in lower production as plants do not grow as rapidly in the spring or after grazing. Legumes have a high potassium requirement and low potassium levels can contribute to legume loss from the pasture.

Some Ontario soils have high levels of potassium and pastures grown on them require no additional sources. Animal manures are a good source of potassium and regular applications reduce the fertilizer requirement. Potassium can be applied as part of a spring fertilizer (i.e. 18-6-18) or as muriate of potassium (0-0-60) in late summer to stimulate storage of root reserves. Legumes (especially alfalfa) can be "luxury consumers" of potassium. If excessive levels of potassium are available in the soil, plants will extract the potassium in preference to elements such as calcium and magnesium. Plants with elevated potassium levels and low levels of magnesium can cause grass tetany. If large amounts of potassium fertilizer are required, apply them in the fall in order to reduce the chance of grass tetany occurring.

MAGNESIUM

Magnesium is a minor element that is sometimes deficient in pasture forage. It is essential to plant and animal metabolism and deficiency in the plants can result in "grass tetany" in the animals. This is a concern in spring when grass pastures are growing rapidly and their roots cannot take up sufficient magnesium to maintain normal levels in the shoots. Pastures growing on soils formed from calcitic or acid parent materials are most at risk but grass tetany should not be discounted during rapid spring growth in pastures on dolomitic limestone. Magnesium is sometimes added to pastures as a fertilizer but is usually applied as dolomitic lime.

SULPHUR

Sulphur is a minor element that is required for plant growth and is deficient in Ontario soils. Plants deficient in sulphur are a lighter green to yellow with leaf chlorosis. Legumes, especially clovers, are most sensitive to low levels of sulphur. While Ontario soils are deficient in sulphur plants rarely show deficiency symptoms as fields receive sufficient sulphur from acid precipitation. Areas of northwestern Ontario (districts of Thunder Bay, Rainy River and Kenora) do not receive sufficient sulphur in this form for good plant growth. It must be added as a supplement to lime or fertilizer.

SELENIUM

Selenium is an element that is not necessary for plant growth but is required by animals. Ontario soils have very low levels of selenium and animals eating feeds grown on these soils require supplementation with selenium in order to prevent white muscle disease.

NUTRIENT CYCLING

Not all nutrients in the soil are available to the plants. Nutrients may be in organic matter, soil organisms, in freely available chemical forms, tightly bound within the structure of soil particles or bound to the surface of soil particles. This is not a static situation but rather a dynamic one as soil organisms (earthworms, insects, and other invertebrates) digest organic matter added to the soil. Their byproducts, and as they die, themselves, are in turn digested by soil microorganisms (fungi, bacteria, etc.). These microorganisms are digested by other microorganisms or decompose into elements that enter the soil chemistry. Within the chemistry some elements form tight chemical associations with soil particles while others are relatively available for plant uptake. Healthy, fast-growing pastures have a very active soil organic matter and soil chemistry as new organic matter is regularly added to the system. Because the cycle is so complex it is impossible to determine the exact status of the entire system at one time. The level of organic matter in the soil (undigested plant material, macroorganisms and microorganisms) can be measured as well as the level of nutrients available to plants in the soil.

Soils should be tested regularly to determine the levels and the balance of various nutrients in the soil. This allows you to increase the nutrients that are at insufficient levels and prevent the over-application of elements currently at satisfactory levels. If records are kept, soil tests can be used as a management tool. They will show which elements are being raised over time or which are being depleted. Changes can be made to the fertility program to prevent the depletion of nutrients and the "run-down" pastures that result.

SOIL TESTS

A basic soil test that measures the pH, phosphorus and potassium levels is sufficient for most pasture management. Soil tests for northwestern Ontario should include sulphur testing. Further tests may be beneficial if a specific deficiency is suspected, but are not required on a regular basis.

FERTILITY PROGRAM

Phosphorus and potash should be applied according to the soil test recommendations. Nitrogen should be applied according to yield goals, the cost of nitrogen and the value of the animal product being produced on the pasture. The economics of using nitrogen on pastures depends on the utilization of the additional production. This normally requires high stocking rates. For full-season production apply nitrogen in the spring, the end of June and the middle of August. A light application in early September can build root reserves to help grass pastures overwinter and get off to a faster start the following spring.

pH

The pH is a measurement of the acidity or alkalinity of the soil. Most of the pasture species are most productive at pH's in the range of 6.0 to 7.5. A pH below 6.0 is low or acid while a pH above 7.5 is high or alkaline.

If the pH is too low to successfully grow a desired species, it can be raised with the addition of lime. Calcitic lime raises the pH and adds calcium to the soil while dolomitic lime raises the pH and adds both calcium and magnesium to the soil. Liming the soil to raise the pH of acid soils may cause the fertility of the soil to increase as phosphorus becomes more available at near neutral pH and soil microorganisms are more active. Soils in northern Ontario generally require lime, as the pH is low. Soils in southern Ontario may require lime – a soil test will confirm the pH and lime requirements.

Lime is slow acting in the soil. It is best incorporated throughout the root zone and is of limited value when applied to the surface without incorporation. Once applied, the lime will raise the pH for several years, but with time the pH will gradually fall to the original value.

Soils that are alkaline or have a high pH can limit plant growth, although this is rarely a problem for pasture production. High pH soils may be deficient in micronutrients. If this is the case, it is more economical to add the micronutrient than to adjust the pH.

THE IMPACT OF GRAZING ANIMALS ON PASTURE FERTILITY

Most of the nutrients that animals eat while on pasture are returned to the ground in either urine or in dung. The recycling of nutrients through animals can prove to be either a valuable fertilizer source or the cause of tremendous pasture waste. If not managed correctly, the fouling of pastures can cause selective grazing and the deterioration of the pasture.

Areas in the pasture that are contaminated with urine are not usually rejected by animals. Sheep actually prefer to graze these areas. There may be a change in plant composition in the affected areas because of the high nitrogen content in urine. Urine patches receive the equivalent of 300 to 500 kg of nitrogen per hectare. This level of nitrogen stimulates grass growth for up to 4 months and may depress legume growth. In hot weather, grasses and legumes may be scorched and killed by urine.

Plants growing in the vicinity of dung are avoided by animals and are left to mature. Grasses normally dominate in these ungrazed areas as their growth is enhanced by the nutrients in the manure. The area left ungrazed can be several times larger than the area covered by dung and depends on the climate (which affects how quickly the dung is broken down), and the stocking rate. In fields with low stocking rates, pasture losses because of fouling can be as high as 45%. Under high stocking rates, the loss is reduced to 10% or less. In high stocking rate situations there is competition among the animals for feed and they are forced to graze closer to the dung. More importantly, the higher density of hooves breaks up and distributes the dung across the pasture. The effect of dung on the grazing behaviour of animals can continue on long after the apparent disappearance of the dung from the pasture. It can take two pasture seasons before an area that was contaminated is no longer rejected (Figure 5). Often the areas between dung patches are overgrazed.

The pasture underneath dung deteriorates quickly as the plants die from being smothered, or are killed by the high nutrient levels. The area killed will be taken over by plants growing close by or from seeds in the soil or in the dung. Bare patches in a pasture provide an opportunity for weeds to establish. There are extremely high rates of nutrients from urine and dung deposited in the areas where animals camp in the pasture. After a period of time the "camp" may become bare ground surrounded by mature grass and weeds.

Regular harrowing with chain harrows or drag harrows pulled upside down will spread the dung and prevent damage to the pasture and wasted forage. In addition, the fertilizer value of the dung will be utilized.

Horses foul the same part of the pasture throughout the entire grazing season. Forage wastage can be reduced by providing a small grazing area at the start of the season. This will reduce the area that horses leave for droppings and therefore maximize the grazing area.

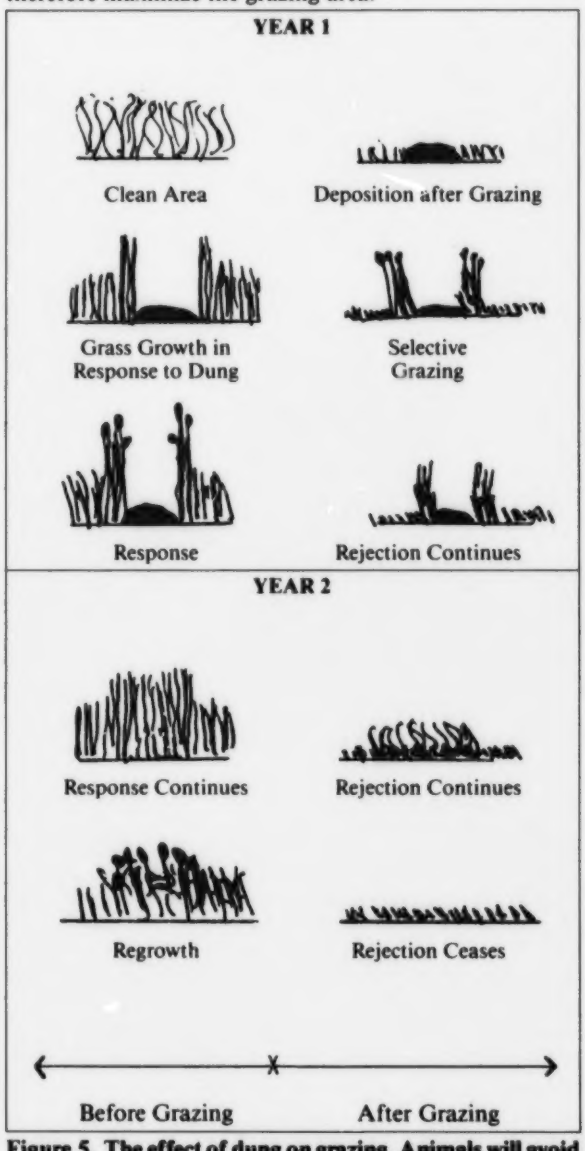


Figure 5. The effect of dung on grazing. Animals will avoid grazing areas contaminated with dung for a long period of time.

WEED CONTROL

Weed control in pastures starts with selecting forage species adapted to the physical characteristics of the pasture and managing them so that they stay vigourous and able to out-compete the weeds. Maintaining 10 to 25 cm of dense forage growth with a good pasture rotation reduces or eliminates the opportunity for weeds to grow.

CONTROL OF WEEDS

To control weeds in a pasture it is necessary to first determine the state of the desirable plants and the extent of the weed problem. If the desirable legumes and grasses are not growing well, it is essential to assess whether growing conditions or management practices are responsible for their poor growth. Corrections to pH, drainage, fertilizer, grazing management or in the forage species themselves can then be made in order to develop a thick, competitive pasture.

Certain plant species are called indicator plants because they will grow in conditions that most other plants will not (i.e. wild strawberries are indicative of low phosphate levels and moss grows on land with very low nitrogen levels). **Weeds are indicators of a problem. Correct the problem to allow the forage to grow and reduce the weeds.**

Management problems usually consist of over- or undergrazing. Overgrazing occurs when animals graze the forage down to the ground. The forage is slow to recover and weeds that have good root reserves grow faster. The effects of overgrazing are usually seen by midsummer. The pastures have been grazed several times, forage root reserves are low and growth is further slowed by hot, dry weather. Perennial weeds with root reserves that have not been used will grow. Chicory is an example of this type of weed. Undergrazing allows the forage to overmature and become reproductive. As the forage flowers and sets seed, growth slows and weeds can outgrow the forage. In the case of either over- or undergrazing, changing the rotation to keep the forage between 10 and 25 cm will reduce the opportunity for weeds to grow.

TYPES OF PASTURE WEEDS

The most important part of weed control is recognizing the weeds present in the pasture and knowing their growth habit. Understanding the way a plant grows allows you to control it's growth and spread.

Annual weeds germinate from seed, grow, flower and set seed during one growing season. Usually they grow quickly in the spring and compete heavily with crops. They can be a problem when establishing pastures, as most need a disturbed seedbed to grow, but are rarely a problem once the pasture is established. Pastures that are being established can rely on cover crops or herbicides to control weeds in the first weeks. Direct-seeded pastures can be clipped once the forage is established. Most annuals will not regrow after clipping.

Winter annual weeds can be difficult to control in pastures. They germinate in late summer or fall and grow leaves (usually a rosette) in the fall when there is little competition from the pasture. They overwinter as a living plant and resume growing actively as soon as temperatures allow, usually before the pasture starts to grow. Control is obtained with a chemical herbicide in the fall or by clipping the weeds in the spring or early summer to prevent seeds from developing.

Biennial and perennial weeds cause the most problems in pastures, as they grow in periods when the pasture species are dormant and non-competitive. Growth of these weeds may be slow the first year or for several years, until the plant establishes root reserves. During following years, the plants send up shoots during periods of low competition from the forage. Plants like dandelions establish a large fleshy storage root to provide energy for early spring growth. Perennials can also spread by underground stems and roots. Watch for patches of weeds like thistles that spread by underground roots.

METHODS OF WEED CONTROL

Most weeds can be removed by clipping. Annuals clipped at flowering are prevented from going to seed and generally will not regrow. Perennials may have to be clipped several times - often over a period of several years. Repeated regrowth and clipping depletes the root reserves of the plants and will eventually make them less competitive than the pasture species.

Chemical controls must be applied at the appropriate growth stage and time of year. Consider the effects of the herbicide on the forage species and the withdrawal time - the period after application during which the pasture should not be grazed. A chemical may have to be applied more than once to kill established perennial weeds. Generally, legumes are damaged by chemical treatments.

Most chemicals are applied in the early spring or late fall when the pasture is dormant but the weeds are actively growing. Spring application can be difficult if the pasture is wet and there is a possibility of runoff. Fall applications must be made after the pasture is dormant but while the weeds are still actively growing. For a full discussion of weed control refer to OMAF Publication 75, *Guide to Weed Control.*

EFFECTS OF WEED CONTROL

Removal of weeds by mechanical or chemical means is a short-term solution. Long-term control relies on removing the problem weed and managing the pasture to prevent re-establishment. Removal of weed species does not necessarily improve yield immediately, as weeds often add to total pasture production. If the majority of a pasture was weeds killed by a herbicide, it is necessary to reseed to prevent other weeds from becoming established on the bare ground. Long-term weed control consists of a combination of chemicals, fertility, grazing management and reseeding if necessary.

Weeds do not need to be controlled if they are not damaging the pasture. The decision to control a weed is based on determining how much damage it is doing by lowering the yield. If the presence of the weed is not lowering overall yield of the pasture, it may be advantageous to leave it and consider it a forage plant. Dandelions growing in a rough grass pasture may be providing early feed for animals.

Changing your thinking about the weeds is adequate control.

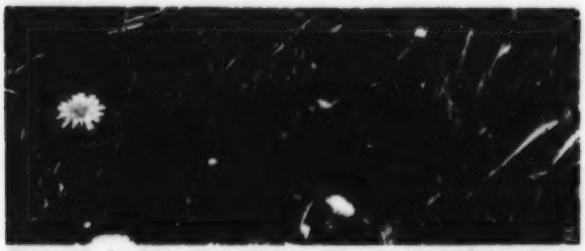


Figure 6. It does not always pay to control weeds in pastures and weeds like dandelions have good feed quality and are palatable.

NON-PASTURE AREAS

Weed control should not be limited to the pasture. Fencerows and waste areas are good reservoirs of seed and give perennials an opportunity to grow underground roots out into pasture fields. Clipping these areas once or twice a year will keep most weeds under control. Areas that are being left uncut for natural regrowth or wildlife habitat should be checked for weeds and individual plants controlled.

WEED CONTROL DURING PASTURE RENOVATION

Weed control during renovation differs from normal weed control. During renovation the young species will be poor competitors and susceptible to weed competition. Chemical and mechanical weed control may be used until the pasture plants are well established and competitive. The pasture should be watched closely to ensure the weeds do not out-compete the pasture species. Alternatively, animals may be used to keep all existing plants grazed down to allow the new species to become established.

POISONOUS WEEDS

Not all plants are benign and some are poisonous to animals. The toxicity of plants varies with the amount of plant ingested, growing conditions and animal health. Symptoms of poisoning include restlessness, loss of appetite, chills, tremors, etc. See the OMAF Factsheet, *Common Weeds Poisonous to Grazing Livestock Part A and Part B*, Agdex 130/643 for a description of these weeds, where they are generally located and the symptoms of poisoning. IF YOU SEE ANY INDICATONS OF POISONING CONSULT A VETERINARIAN.

Poisonous plants are normally eaten when pasture conditions are poor and there is little else for animals to eat. Special care has to be taken if animals have access to wooded or swampy areas where poisonous plants can be growing without competition.

Not all poisonous weeds have to be eaten to harm animals – some cause dermatitis. Watch fencerows and waste areas. Horse owners should watch trails and riding areas for plants that cause rashes, inflammation and animal discomfort.

POISONOUS PLANTS SHOULD BE CONTROLLED IF THEY ARE GROWING WHERE ANIMALS HAVE ACCESS TO THEM.

TRAMPLING EFFECTS

Livestock affect a pasture and its productivity in more ways than by just grazing. The action of animals walking or running across a pasture can be damaging. Trampling physically hurts plants and it is easy to see the full effects of the damage on frequently travelled paths, near watering spots, mineral feeders or gateways. Some plant species such as alfalfa, red clover, and timothy are very susceptible to this type of damage while bluegrasses, creeping red fescue, tall fescue, perennial ryegrass and white clovers are fairly resistant. The differences in tolerance to trampling can produce changes in the plant make-up of the pasture. The susceptible species die out and are replaced by the resistant species or new plants that germinate from seed in the ground. High stocking rates can depress yields because of trampling damage (Table 11).

TABLE 11. Effect of Trampling Damage on Summer Dry Matter Yields (kg/ha)

Sheep per hectare	Grasses		
	perennial ryegrass	orchardgrass	other grasses
0	840	110	270
40	800	40	120
80	760	30	120

Source: Edmond, D. The Influence of Animal Treading on Pasture Growth. Proceedings of the Xth International Congress, Helsinki, Finland, pp. 453-458.

High stocking rates can lower yields because of trampling damage.

Trampling can also damage a pasture by causing soil compaction and puddling (the reduction of air or water-filled pore spaces in the soil). Plants are adversely affected because there is less oxygen available for their roots, fertilizer and water movement in the soil are depressed, nitrogen fixation is reduced and root growth is impeded. Plants on compacted soils develop more roots at shallower depths and become susceptible to dry weather. This type of trampling damage occurs when pastures on silt, clay, or soils with a high organic matter are grazed during wet conditions. The damage escalates as the size and number of animals grazing the pasture increases.

To keep trampling damage at a minimum follow these management practices.

- Ensure a good level of soil fertility.
- Use tolerant grasses and legumes on fields prone to trampling damage or for heavy traffic areas (Figure 7).
- Improve field drainage where practical.
- Use controlled grazing to encourage the development of a dense, healthy pasture.
- Use one area as much as possible for grazing during wet periods in order to limit the area exposed to trampling damage.

Figure 7. Areas where horses are worked or exercised should be seeded to mixtures with sod-forming grasses.

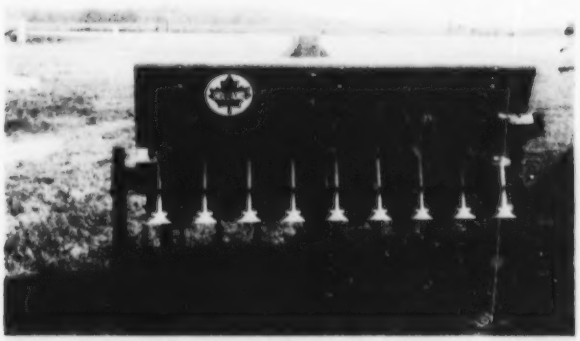


Figure 8. Machines for mechanically slitting the soil help to alleviate the effects of soil compaction.

Much of the damage to the soil from trampling is repaired by frost action and the activity of worms and other life forms in the soil. If these are unable to overcome soil compaction and puddling, there may be a benefit from mechanically slitting the soil (Figure 8).

GRAZING MANAGEMENT

ANIMALS AS GRAZERS

Animals affect pastures and pasture productivity by trampling, spreading seeds, recycling nutrients and by grazing. It is this last action that has the largest effect on pasture productivity and survival. Animals generally graze 7 to 12 hours a day and within a livestock class the amount of time spent grazing does not vary much from day to day. The peak periods of grazing are after daybreak, in the late afternoon and around midnight. When the weather is hot, animals spend more time grazing at night. The amount that they eat in a day is dependent on their bite size and the rate at which they eat. When the forage supply and the quality of that forage is good, they will take fewer, larger bites than when the forage is in short supply. When the grazing is good, cattle and sheep take approximately 36,000 bites in a day. Animals can maintain their feed intake as the pasture gets shorter by increasing the number of bites per minute and by grazing for a longer period of time. However, a point is quickly reached when animals cannot eat enough small mouthfuls of forage in a day to meet their nutritional needs.

Animals select the highest quality of forage present when the forage supply is plentiful. They prefer leaves over stems and will try to avoid eating dead plant material, trampled plants contaminated with soil, and plants growing near dung. The different types of animals prefer different plant species, or a different proportion of those plants species in their diet. Animals use sight, smell, texture and taste to choose the plants that they want to eat and if given the opportunity, will eat only what they like. This can result in spot grazing. The plants in the grazed areas are kept in a short, immature, leafy condition and have a high feed quality. Usually there is not enough quantity in these overgrazed areas to satisfy the nutritional requirements of the animals and the plants eventually die from being overgrazed. Plants that are not grazed become mature and less attractive to the animals, and are wasted. With time, the less attractive plants become the dominant plant species in the pasture. As the forage supply per animal decreases, the degree of selectivity decreases. Ideally, stocking rates should be high enough to eliminate most, but not all, of the selective grazing. Animals perform better when there is some opportunity for selective grazing.

Animals have different abilities to be selective grazers. Sheep and goats are the most selective, followed by horses and then cattle. The ability of animals to be selective grazers and to graze plants at different heights is dependent on their mouth parts.

SHEEP

The structure of sheep lips and the way that they use their tongues allows sheep to be very selective. They can easily choose individual leaves over other leaves from the same plant. They prefer to graze plants in the following order: forbs, broadleaved grasses, fine-leaved grasses, sedges, and dwarf shrubs. Their relatively mobile upper lip allows them to graze pastures closely. They are much better at maintaining forage intake on short pastures than cattle.

Figure 9. Sheep should be removed from a pasture when the forage is grazed down to 6 cm.

However, ewes need at least a 550 kg of dry matter per hectare available for grazing at all times in order to perform well. Lamb production is very sensitive to forage availability and quality, as they have high nutrient requirements. Finishing lambs needs 1000 kg of dry matter per hectare. Sheep pastures should be no lower than 6 cm in height (Figure 9). If the pasture is thin, this minimum height should be increased.

GOATS

Goats have a similar ability to sheep to selectively graze but prefer a wider range of plants in their diet. They are able to adapt to grazing browse more easily than sheep or cattle. Up to 80% of their diet can be from small tress and shrubs. Milking goats however, have high protein and energy requirements and should be grazed on pastures with high quality forage at all times.

HORSES

Horses graze more selectively and can bite plants off closer to the ground than cattle. They tend to be spot grazers, grazing one area close to the ground and leaving other areas. Under low stocking rates the field develops a pattern of heavily grazed and lightly grazed areas. They generally prefer grasses over legumes and prefer to graze complex mixtures. They spend a longer time grazing than ruminants. A mature horse needs up to a hectare of productive pasture for the entire grazing season; heavy horses require an additional hectare. Horses need space to run and paddocks should be designed with this in mind. They need relatively large areas and long rectangular paddocks are preferable to small, square paddocks (Figure 10).

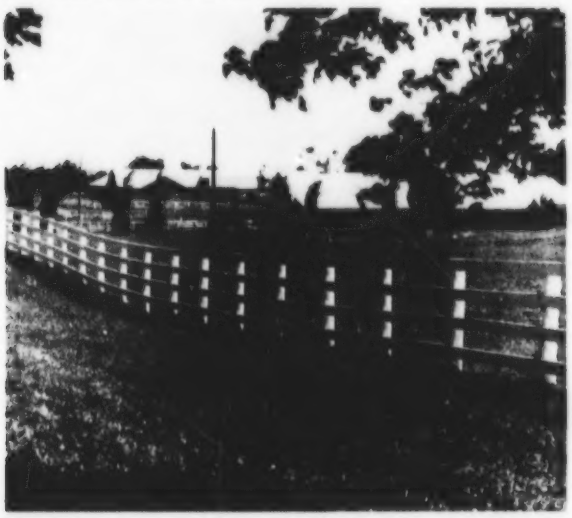


Figure 10. Horse paddocks should be designed to allow the animals room to run.

CATTLE

Cattle use their tongues to pull plants into their mouth and because of this are unable to graze as selectively as sheep, goats or horses. In addition, they are less able to maintain feed intake when grazing short plants. Cattle should graze pastures that are 10 to 30 cm tall (Figure 11).

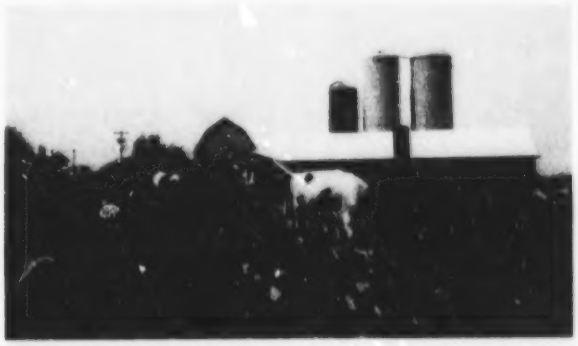


Figure 11. Cattle should graze forage that is between 10 to 30 cm tall.

The ideal height ranges from 12 to 15 cm. At this height range, mature animals graze at a rate of 70 to 80 bites per minute and eat 70 kg of forage in a day. Cattle are able to eat at this quick pace because they can easily form a food bolus and swallow the feed without lifting their heads. When pasture plants are tall (30 cm +) cattle have difficulty in forming a food bolus (Figure 12). They must lift their heads up to form the bolus and swallow. This reduces the number of bites they are able to take per minute and reduces feed intake to 30 to 40 kg per day. When grazing short plants (less than 8 cm) cattle will only eat 15 to 20 kg of forage per day. Cattle grazing plants shorter than 10 cm cannot get enough energy or protein to meet their daily requirements (Figure 13).

Figure 12. While there is lots to eat, the quality is poor and these stockers will lose weight while grazing this field.

Figure 13. These calves no longer have enough to eat and should be moved.

Cattle prefer to graze fine grasses over broadleaved grasses or legumes. They like to change the area that they graze frequently. Therefore, rotational or strip grazing suits cattle. Milking dairy cows should not stay longer than two days in the same paddock and ideally should get fresh pasture at least once a day. Top producing pastures can support two milking cows per hectare for the grazing season. Dairy heifers and dry cows do not have to move as frequently as the milking herd and can stay a maximum of seven days in a paddock or field. Beef cattle benefit from being moved every three to four days and should not be left longer than seven days in a paddock or field.

THE EFFECTS OF GRAZING ON PLANTS

Plants use water and carbon dioxide in the presence of sunlight to create carbohydrates and oxygen (a process called photosynthesis). The plant uses the carbohydrates as an energy source for growth. When plant growth slows and there are more carbohydrates produced than needed for growth, the surplus carbohydrates are stored. These reserves are important for the plant's survival over winter and for the initiation of plant growth in the spring. Regrowth after grazing depends on the energy being produced by the remaining leaf area or from the carbohydrate reserves. **The aim of grazing management is to harvest the plants while leaving enough top growth and root reserves to support fast regrowth.**

Plant growth in the spring or after close grazing starts slowly. Carbohydrate reserves stored in stem bases, roots, rhizomes and stolons have to be mobilized before they can be used to fuel growth. In grasses, the dependence on reserves for regrowth usually lasts for two to seven days while in legumes it can be two to three weeks. Once leaf area develops, growth quickens as the plant has an immediate source of energy from photosynthesis. After this vegetative period of fast growth is over, the plant becomes reproductive, growth slows and carbohydrate reserves are replenished. Grazed plants left with enough leaf area to continue photosynthesising regrow at a quicker rate, as they are not dependent on carbohydrate reserves.

Plants that are frequently closely grazed can be damaged because they are unable to restore their carbohydrate reserves. With each defoliation the plant's reserves are reduced and with time depleted. In addition, any intensity of grazing causes plant root damage; root weight, length and vigour are reduced. The extent of the damage increases with the severity of the defoliation. Loss of roots slows plant growth as the plant cannot obtain sufficient water or minerals to support rapid growth. Severe overgrazing removes so much of the leaves that there is insufficient energy produced to keep the roots alive and the plant is unable to survive. **An important part of grazing management is to allow the plants adequate time to recover from being grazed.** The amount of time needed for this will change during the pasture season. Plants grow at different rates during the grazing season due to changes in growing conditions.

The stage of growth that grasses are grazed at influences how well they will survive and regrow. Grasses are made up of individual tillers each having a growing point (which controls the growth of the tiller and which may form a seed head), a stem, leaves, roots and dormant buds. In the vegetative growth stage the growing points are close to the ground, safe from being eaten, and are able to produce new leaves after being grazed. Growing points continue to produce new leaves until the plant goes into the reproductive stage or until the growing point is elevated by stem elongation. With grasses such as Kentucky bluegrass, tall fescue and orchardgrass, stem elongation occurs as the plant goes into the reproductive phase. Forage production from these grasses is encouraged by frequent grazing. Grasses such as timothy, bromegrass and reed canarygrass elevate their growing point early in their growth and regrow slowly if grazed too early (before the boot stage). New growth must come from the dormant buds and the energy for that growth must come from the remaining leaf area or from reserve carbohydrates. These grasses are suited for conrolled grazing where they can be harvested quickly and given a rest period in which to recover and regrow.

GRAZING MANAGEMENT SYSTEMS

Grazing management should balance livestock demand with forage availability, promote rapid pasture regrowth during the grazing season and long-term pasture persistence. The art of grazing management is to ensure that there is sufficient pasture in a stage suitable to graze at all times throughout the grazing season. Several grazing management systems define different methods of harvesting the forage.

CONTINUOUS GRAZING

In North America continuous grazing means putting a set number of animals out on a pasture and leaving them there for as much of the season as the pasture will support them. The number of animals that the pasture can support is determined by the forage yield during the period of poorest pasture productivity, usually July and August. In most cases the stocking rate needs to be very low or the animals will lose weight during the summer. Individual animals can milk or gain well under this type of grazing management if the stocking rates are low enough. The drawbacks to this type of grazing management are:

- Meat or milk production per hectare is very low
- Most of the forage produced in the spring is wasted
- The animals selectively graze and cause the pasture to become less productive with time

Continuous grazing in Great Britain has a different meaning. The animals stay in an area for a long period of time but the size of the area available for grazing is constantly adjusted by moving fences. The manager makes a larger area available when the forage is slow growing and makes less available during periods of fast growth. Surplus pasture is harvested as stored feed. An alternative is to add or subtract animals as determined by pasture productivity. Growth is measured by taking the height of the pasture. If the plants are taller than the target height, more animals are added; if the plants are shorter, animals are taken out. This form of continuous grazing requires that the manager check pasture growth daily and have a flexible approach to harvesting the forage or have additional land for pasturing livestock. This is one form of controlled grazing.

The advantages of controlled grazing are:

- More of the produced forage is used
- Higher numbers of animals can be supported by the pasture
- More meat or milk is produced per unit of land
- The pasture recovers quickly after being grazed and remains productive for a longer period of time
- It favours taking a hay or silage cut if there is an excess of forage in the spring
- Desirable legumes and grasses are able to persist from year to year

ROTATIONAL GRAZING

Rotational grazing involves fencing a pasture into several small paddocks. Subdivision is a useful way to balance the livestock needs with the forage supply. The livestock graze the paddocks in sequence, moving to a new paddock when the forage is ready to be grazed. In general, livestock should go into a paddock when the forage is 25 to 30 cm tall and be removed when the pasture is grazed down to 8 cm. A relatively high stocking rate for the size of the paddock forces the animals to be less selective in their grazing and to graze the paddock off evenly. The animals are removed before they start to graze new plant growth and the paddocks are rested.

Dividing the fields allows some of the paddocks to be harvested for hay early in the season. This hay can be fed back if and when the pastures do not produce enough forage for the livestock. When planning the area to be cut, consider how much area will be needed to support the livestock until the hay aftermath is ready to be grazed. The later the first cut, the slower the regrowth. This delays putting the cut area back into the pasture rotation and puts extra pressure on the grazed area.

Rotational grazing does not necessarily increase daily liveweight gains but does allow a heavier stocking rate to be carried.

STRIP GRAZING

In this system the animals are given just enough pasture to supply a half a day or a day's requirements. The fence is moved once or twice a day to provide the animals with fresh forage. A second wire can "follow" the animals to prevent movement back onto grazed areas. While this is the most labour intensive method of grazing it results in the highest quality feed, the least waste and the least damage to a pasture.

FORWARD GRAZING

This is a variation of rotational grazing where the pasture is grazed by two groups of animals.

The first group into a paddock are those with the higher nutritional needs. They graze the tops of the plants, the most nutritious part, and are not forced to graze forage of lower quality. The second group, who have lower nutrient requirements, graze the forage left by the first group. This system works well where milking cows are the first to graze a paddock with dry cows or heifers used to clean up the pasture.

CREEP GRAZING

Young animals are allowed access to pastures ahead of their dams. This sytem provides higher weaning weights when forage is limited and in situations where there would be competition between the young stock and the dams for pasture. It can be set up fairly easily by either installing creep gates or by putting the division fence high enough in mid to late summer to allow young animals to be first grazers.

MOB GRAZING

This is a form of rotational grazing. Very large numbers of animals graze the paddocks and are left in a paddock until all the forage is grazed down evenly and closely. This approach is normally used to clean up pastures that have a lot of coarse, mature plants. Mob grazing can replace clipping.

MIXED GRAZING

This approach to grazing management takes advantage of the fact that different types of livestock like to graze different plants. Two or more types of animals graze the paddock at the same time or follow one another through the paddocks. Sheep and cattle make a good combination. Sheep should not be grazed with horses.

DESIGNING A ROTATIONAL GAZING SYSTEM

The first step in designing a rotational grazing system is to take an inventory of the state of the pastures, the layout of the current fences, and the location of the watering and handling facilities. To keep the cost of setting up paddocks as reasonable as possible the existing fencing must be incorporated into the scheme. All paddocks must have access to water and the layout must accommodate this. An alley system (Figure 14) is useful for moving livestock back and forth to a common destination. A central water source can also work extremely well.

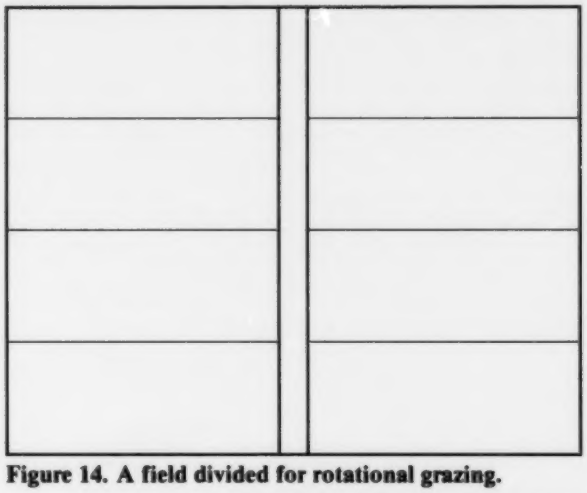


Figure 14. A field divided for rotational grazing.

An alley way allows access to water and handling facilities from all paddocks.

The productivity of the pastures should be estimated. Paddocks do not have to be the same size but it makes it easier to manage them if they have a similar degree of

productivity. Extremely productive pastures should be divided into smaller areas than poorly producing pastures. Paddocks being established on hills should be set up to run across the field rather than up and down. This eliminates the selective grazing that normally takes place on slopes. If given the opportunity, livestock will camp on the top of hills and reject the forage at the bottom.

NUMBER OF PADDOCKS

The number of paddocks that are required is based on the length of time it takes for the pasture to recover after being grazed. This is essential for keeping the pastures productive. A French scientist, André Voisin devised the following simple formula to calculate the number of paddocks required for efficient grazing:

[(Days of rest required / days of grazing in one paddock) + 1] = The number of paddocks required

Length of Rest Period

The number of days required for rest differs over the grazing season. In the spring forages grow at twice the rate that they grow at in the summer. A good working guideline is that it takes 15 to 20 days in the spring and 30 to 40 days in the summer for most forage species to recover after grazing. However, recovery rate is influenced by the individual species, how they have been grazed and the weather. The required rest period fluctuates not only within the season but also from year to year. A good rotational system must be flexible in order to handle these changes.

Days of Grazing Per Paddock

The time the animals spend in a paddock must be long enough to graze the pasture off evenly but short enough to prevent grazing of new regrowth. The faster the animals are in and out of a pasture the better in terms of forage production (Table 12). Seven days is the maximum time that animals should remain in a paddock. The animals should be moved on to the next paddock when it is ready to be grazed even if they have not finished grazing the first. This is to prevent the next field from becoming too mature and being largely wasted by the animals. If the animals cannot keep up to forage production, a hay crop, if possible, should be taken (Figure 15).

TABLE 12. The Effect of the Length of Grazing Period on Dry Matter Yields (kg / ha)

Mixture	Harvest Period Days	May 15	June 15	July 15	Aug 15	Total
Alfalfa + ladino + brome + orchard	1	1880	2210	1870	1960	8090
	7	2190	1420	1690	1630	6930
Ladino + orchard	1	1770	2240	1570	1710	7310
	7	2040	1340	1280	1290	5950
Trefoil + timothy	1	690	2180	1330	1370	5580
	7	940	1380	1200	970	4510

Source: R.S. Fulkerson. Ontario Agricultural College, University of Guelph

Shorter grazing periods encourage higher pasture yields.

Figure 15. Taking a hay crop helps to balance livestock needs with pasture production.

Because of the differences in recovery rates in the spring and the summer, only half the number of paddocks needed in the summer are required in the spring. Haying half of the spring production is one solution to balancing the forage supply with livestock demand. The other option is to expand the land base for summer grazing by incorporating the aftermath of hay fields. Most pasture systems are more effective if they include grazing hay aftermath so as to reduce stocking rates in midsummer.

Paddock Shape

Paddocks should generally be square in shape rather than rectangular or irregularly shaped. Long, thin paddocks tend to encourage livestock to graze at the end nearest the water, minerals or shade and to avoid grazing the distant end. Square corners in a paddock make it easier to carry out haying or clipping. Paddocks should be designed to allow access to machinery for carrying out these operations as well as fertilizing.

At the end of each grazing season evaluate the performance of the pastures. If some of the paddocks are regularly not grazed off evenly, then that individual paddock should be subdivided to encourage better grazing in the next season.

STOCKING RATE

The success of using rotational grazing management depends on having enough animals to graze the small areas quickly. The number of animals this will take depends on the pasture, the complexity of the rotation and the growing season. Too high a stocking rate leads to competition between the animals for forage and results in lowered milk yields or weight gains. A low stocking rate gives top animal performance but poor gains or milk yield per area of pasture. The ideal stocking rate strikes a balance between individual animal productivity and production per hectare. A productive pasture should be able to support 2 animal units per hectare for the grazing season. By planning to carry 1 animal unit per hectare in the summer, a safety factor is built into the system in case of drought. Grazing experience will help determine what the right stocking rates are for a particular pasture.

The concept of animal units provides a way to compare the different classes and types of livestock that are put on pasture. One animal unit is considered to be one mature 450 kg cow with or without calf. An animal unit consumes 12 kg of forage dry matter a day. Table 13 shows the animal unit equivalents for other classes of livestock.

TABLE 13. Animal Unit Equivalents

450 kg Cow - with or without calf	1
Mature Bull	1.5
Yearling Steer or Heifer	0.6
Weaned Calf	0.5
Horse	1.0
Ewes	0.20

CLIPPING PADDOCKS

Coarse plants around dung areas or accumulated on under-utilized areas should be mowed. Mature forage is low in feed quality and is less palatable than vegetative forage (Figure 16). Clipping will stimulate new growth and prevent animal rejection in future grazing periods (Figure 17). If the plants are clipped early enough, the livestock will eat the clippings. Clipping will also help to control weeds.

Figure 17. Clipping pastures produces even regrowth and reduces selective grazing.

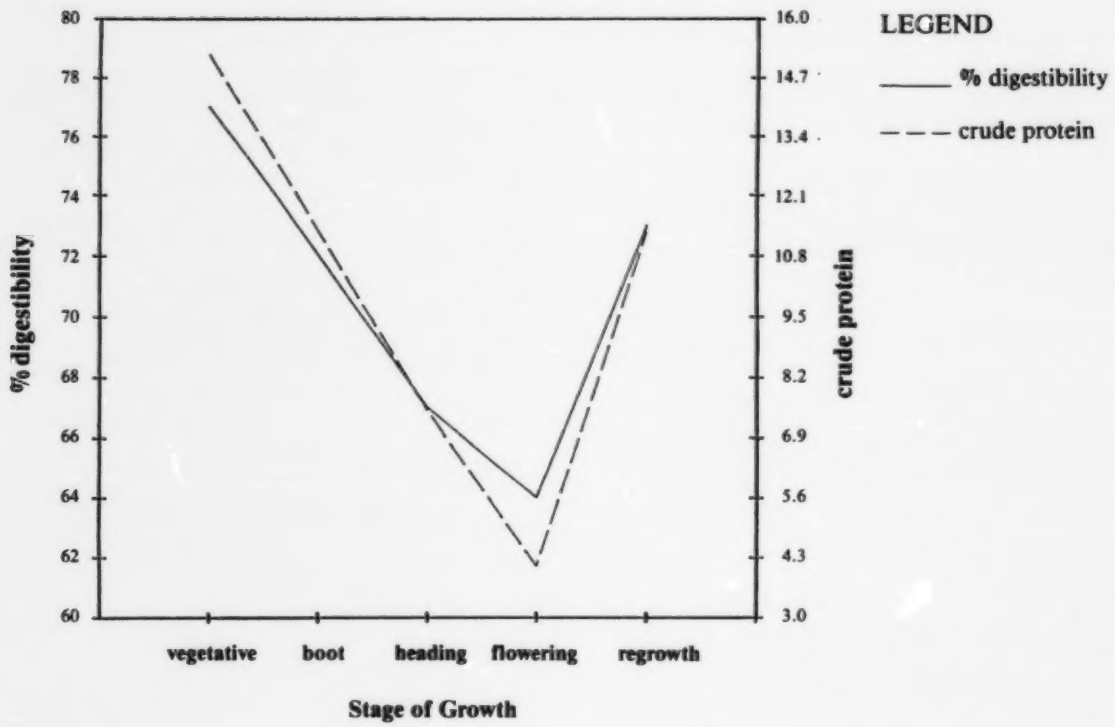


Figure 16. The effect of maturity on crude protein and the digestibility of grasses.

Feed quality drops with plant maturity and does not improve until the plant starts to regrow after being grazed or clipped.

ELECTRIC FENCING

Fencing is the key to pasture management as it allows a livestock producer to rotate pastures and control livestock and predators. Many types of fence are used in Ontario to provide a physical barrier. They include an assortment of cedar rail, stone, page wire, barb wire, suspension, high tensile and board fences.

Livestock farms need at least an exterior or perimeter fence. Interior fences allow a farm to be subdivided and moveable fences add flexibility to the grazing management. Electric fencing offers this versatility and is effective and inexpensive.

Electric fencing can replace worn out fences or be used as a new fence. It will support and extend the life of a page wire or rail fence (Figure 18). The high cost and labour involved in putting up and maintaining traditional fences has made electric fencing more attractive. When properly constructed, modern electric fencing is much more dependable than the older style battery-operated units used in the past.

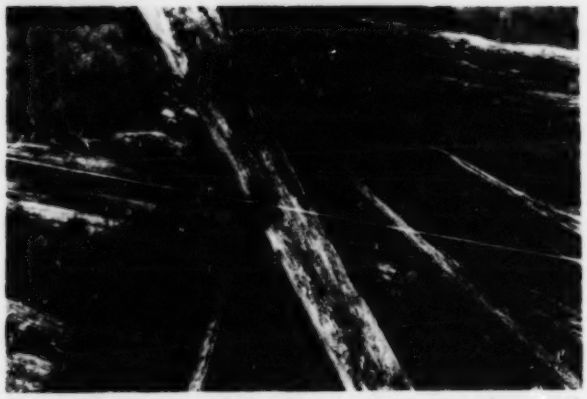


Figure 18. One strand high tensile wire supporting a rail fence.

TRAINING

This type of fence is a psychological barrier rather than a physical barrier. The success of electric fencing depends on the livestock being trained to the fence. Place a charged wire inside the barnyard fence and leave the livestock here a few days to let them learn about electric fences before putting them out to pasture.

HOW DOES IT WORK?

A power source, either hydro or battery operated, is needed to provide a shock. Wire is used to carry the current out along the fence and a ground completes the circuit.

An electric fence line with no vegetation touching it requires very little power to maintain high voltage levels. Normally the fence will have some plant growth to handle, this is called the fence load. Every plant in contact with a live wire will draw a small amount of current to the ground. With miles of wire this power drain can reduce the effectiveness of the fence.

ENERGIZERS

There are many energizers on the market. The type needed will depend on the distance to be fenced and the amount of vegetation on the fence line. The available power source will determine whether a hydro, battery or solar unit is best. Energizers are often rated in miles of wire. A ten mile unit will power 10 miles of single strand fence or 5 miles of double strand fence under no load conditions. Most fences run through bush and long grass. Under heavy load conditions a unit rated for 10 miles may be sufficient for 2 miles or less. Joules more accurately estimates ability to carry current for a long distance. The current on the wire is measured in volts. Cattle require 2,000 volts, sheep 2,500 volts and horses 1,500 volts. All units should have lightning protection against power surges on the hydro line and be kept under cover from the weather.

GROUND

It is extremely important to properly ground electric fences by attaching the ground terminal of the energizer to a ground rod. This allows the current to make a full circle through the live wire to earth to the ground rod and back to the energizer (Figure 19). The ground rod should be 6 feet or more in length. If more than one rod is necessary, the rods should be at least 6 feet apart. The rods should be driven into the ground where the earth is normally damp. Keep the energizer ground 75 to 100 feet from a hydro ground and lightning diverter ground. Use a heavy gauge wire from the ground rod to the energizer. Make sure all connections are clean and free of rust. Clamps should be tight. Most electric fence problems are a result of a poor ground.

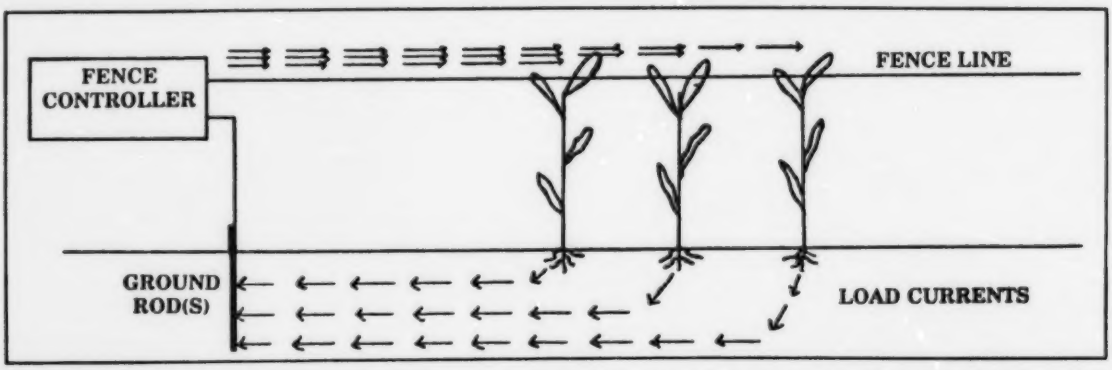


Figure 19. An electric impulse travels from the energizer along the wire to plant or animal to ground to ground rods and back to ground post on energizer.

Under dry conditions it is necessary to run a ground wire on the fence five inches away from a live wire. This ground wire is connected to the ground post on the energizer. When an animal touches both wires it will complete the circuit. This will give the maximum shock.

To test for sufficient grounding, operate the energizer and short out the fence by laying a number of steel rods (or T-posts) on the wires at least 300 feet away from the energizer. If a digital fence tester is available, take a reading between the grounding rod and the soil at least four feet away. The tester should read less than 400 volts. If a tester is not available, touch the ground rod with one hand and the soil with the other. You should not feel a current if the fence is operating properly. If all connections are tight and rust free, keep adding ground rods until there is a low reading or no current is felt.

WIRE

An energizer is only as good as the fence. Current on a fence can be compared to water in a pipe. The larger the pipe the more water it can carry. Larger wire has less resistance to the current. A 12.5 gauge wire has about 1/3 the resistance of a 16 gauge wire. This means it will carry the current a greater distance under similar conditions. The lead out wire from the energizer should be at least 12.5 gauge.

For permanent fences a high tensile wire is best for longevity. It will withstand fallen trees or branches. Polywire, polytape, 14 gauge wire and 16 gauge wire are suitable for temporary fencing. This wire can be rolled up and moved with little effort, especially if insulated hand reels are used. Polywire and polytape are recommended for short stretches of fence. Polytape is quite visible and recommended for horses.

NUMBER OF WIRES

Depending on the type of livestock, at least two wires should be used on permanent fences. One wire will support an existing rail or page wire fence with the use of stand-off brackets. One or two wires are adequate for cross fencing.

WIRE SPACING

One strand of wire 30 inches from the soil will control cows, yearling heifers and horses. Two strands at 18 inches and 36 inches from the soil are often used for cows with calves, young heifers and horses with foals. For sheep and goats a three strand fence at 9 inches, 18 inches and 30 inches is effective.

POSTS

Choice includes cedar, insultimber, plastic, steel stakes, fibreglass and trees. Steel stakes will ground the fence if an insulator is cracked. With trees, leave the nails loose to prevent the tree growing around the insulator. The type of post used should depend on whether the fence is permanent or temporary, the type and number of wires, the distance between posts and cost.

A permanent fence with 2 or more high tensile wires requires strong posts and braces. This is the last line of defense.

A temporary fence should be easy to set up and take down. Plastic or fibreglass posts are flexible.

This distance between posts will vary with the lay of the land. Posts can be placed 100 ft apart on level land. A strong post is needed to carry the weight. A cedar post with a 5 inch or 6 inch top or insultimber is satisfactory. Spacers are placed between posts to keep wires equal distance apart. On rolling land, posts are closer to enable the fence to follow the hills and valleys. Put posts at right angles to the ground surface on slopes to maintain the fence height.

BRACE POSTS

With a high tensile, smooth wire fence, the wire load is directly on the brace posts. The wires are suspended on posts by the insulators and move freely. This means the brace posts must take the brunt of any force on the wire and the weight of the wires. With page wire or barb wire, the load is on each staple as it is attached to the post.

Tests done by Alberta Agriculture show that two brace designs are stronger than the rest. They are the 10' diagonal end-brace and the 10' single span horizontal end-brace (Figure 20).

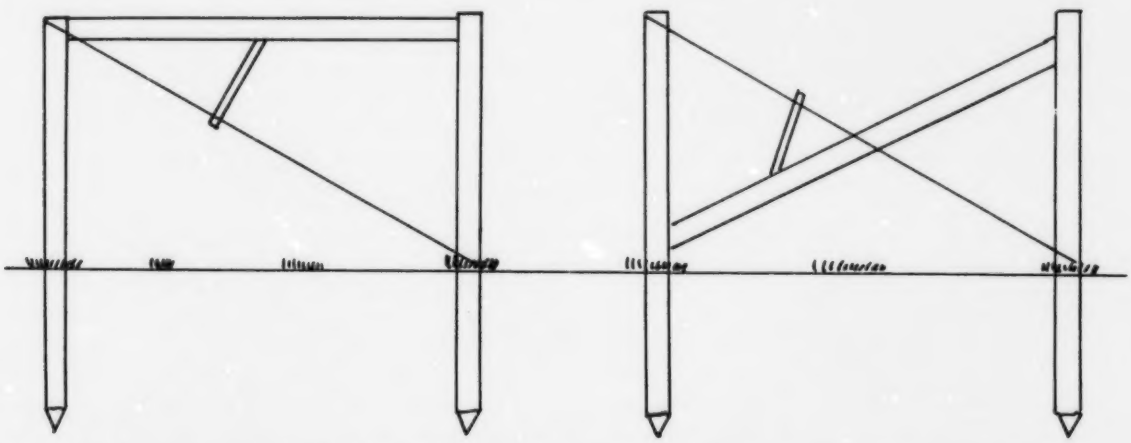


Figure 20. 10' diagonal end-brace and 10' single span horizontal end-brace have proven most effective.

The double span end-brace was given a lower rating because of the extra difficulty and expense of construction. Also all three posts must be directly in line to be effective.

Soil type has a bearing on the effectiveness of an end-brace. Friction between the soil and the post is the key. Heavy clay provides a lot of friction while sandy soil has less. Larger end posts are advisable in sandy soil.

INSULATORS

Except for self-insulating posts like plastic, insultimber or fibreglass, insulators are necessary. Insulators hold the wire to the post and prevent it from shorting out on the post.

Insulators are usually porcelain or plastic. Porcelain will last longer but breaks more easily. Nylon, polyethylene and fibreglass are also available. Insulators with protection from ultraviolet rays will last longer.

Wire should move freely through the insulator. This allows the entire fence to absorb the force of a fallen tree or charging animal.

GATES

Gates may consist of a wire spring or polytape with a handle. The gate must be visible. A hot wire is often run underneath the gate opening through insulated cable. This leaves the fence charged if the gate is open.

LOCAL REGULATIONS

A number of townships have bylaws on the use of electric fencing. Checking at the municipal office will avoid surprises.

PROTECTION FROM LIGHTNING

Clouds build high charges (millions of volts) during a thunderstorm. These charges are neutralized by arcing to another cloud or to the ground.

An energizer can be struck by lightning in three different ways. One is a direct hit on the electric fence. The longer the fence, the more likely a strike. Lightning may strike a building or tree near the fence, inducing very high voltages along the wire. Also the power line serving the farm may be struck sending a surge through the power cord to the energizer. Well-constructed energizers will have built-in protection against power line surges and strikes near the fence line. This type of unit is effective if properly grounded. The energizer however, has no protection against a direct hit on the fence line. For a farm with a very long fence or in a lightning-prone area, external protection is highly recommended.

The following methods have proven successful:

1. Choose a position 300 to 400 ft from the energizer along the fence line. Construct a separate ground system. Connect a lightning arrester between the fence and the separate ground (Figure 21). Lightning arresters are available from farm supply dealers.

2. Place the separate ground closer, but not less than 100 ft from the energizer. Install the lightning arrester. Install a lightning diverter coil or choke in the line anywhere between the arrester and the energizer (Figure 22).

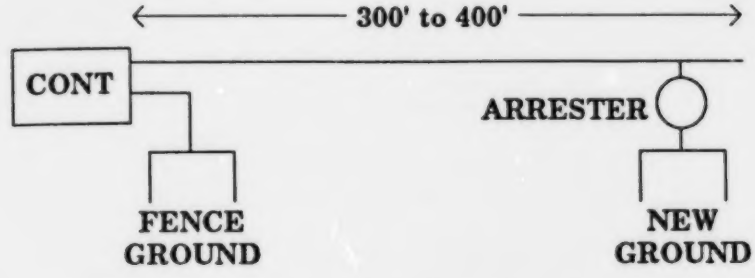


Figure 21. Lightning protection showing arrester and ground.

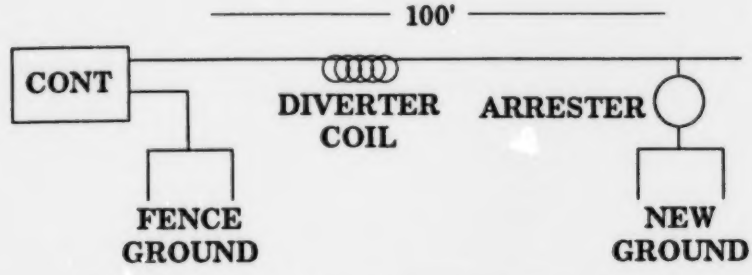


Figure 22. Lightning protection showing arrester, ground and a diverter coil.

PREDATOR CONTROL

Few fences are 100% predator proof. A five wire fence is the minimum for controlling dogs and wolves. Wires placed at 6 in, 12 in, 18 in, 26 in and 36 in from the soil are effective. The bottom wire is a ground wire. A ground wire in contact with vegetation is not a drain on the charge.

FENCING MAINTENANCE

Maintenance will add years of life to a permanent fence. Loosen the wire tightener after the pasture season. This reduces stress on posts and insulators and helps to avoid cracks in the wire. Wire will contract with cold winter temperatures. Check the fence line in early spring for fallen trees, and for contact with old wire fencing, posts or trees. Check ground connections for dirt and rust build-up. Energizers should be stored at temperatures above freezing when not in use.

PASTURE LAYOUT

Put paddock gates at the corner of the field closest to the central water source or holding area. This avoids animals getting trapped on the way to the holding area.

Lanes should be only as wide as necessary. A 15 ft lane will do for 35 cows or 350 sheep. Keep in mind the equipment required in pasture management when building laneways.

Locate lanes on high ground. It is easier to move livestock and equipment, especially in early spring and fall.

Square-shaped paddocks require less fencing material than long, narrow paddocks.

Fence areas of similar topography. If one area has a level field and a slope, separate the two areas. This will prevent the overgrazing of one and the undergrazing of the other.

WATER SUPPLY ON PASTURE

Water is an essential part of every animal's diet. An animal will die more quickly if deprived of water than food. A newborn animal is made up of 75-80% water while 50% of a mature animal is water. Water is needed for digestion, the absorption of nutrients, waste disposal and the regulation of body temperature. It is essential that pasture animals have an adequate source of clean water available at all times.

The amount of water required by animals is effected by body size, milk production, feed intake, maturity of the plants being grazed and the weather. The average daily water requirements for livestock can be found in Table 14.

TABLE 14. Livestock Water Requirements

Dairy	136 litres / head / day (30 gallons / head / day)
Beef Cows	68 litres / head / day (15 gallons / head / day)
Beef Stocker	41 litres / head / day (9 gallons / head / day)
Sheep	14 litres / head / day (3 gallons / head / day)
Horse	55 litres / head / day (12 gallons / head / day)

Source: OMAF Factsheet, Livestock Watering Devices, Agdex 400/716.

Animals obtain some of their water requirements from their feed. Livestock grazing young, lush pastures will not need as much drinking water as animals grazing old, dry plants.

Hot temperatures, long hours of daylight and high relative humidity increase the drinking water requirements while rainfall decreases demand.

Most livestock drink very little at night and given free access to water, will drink between grazing cycles. Beef cattle will drink 4 to 6 times a day while high-producing dairy cows will drink an average of 10 times a day. In dairy paddocks it is important that the source of drinking water be close at hand. Beef cows and calves can travel up to 1.6 km to get water before production is affected. Beef stockers should not have to go more than half that distance. Sheep and goats drink very little when on pasture and can travel over 3.5 km to get water.

Providing good, clean water on dry footing will help prevent the spread of such diseases as foot rot. Muddy ponds, dugouts or stream banks provide a good medium for the spread of diseases.

BLUE-GREEN ALGAE POISONING

Animals drinking from standing water in the summer are exposed to the possibility of being poisoned by blue-green algae.

Long periods of warm weather and a high content of organic matter in slow-moving or stagnant water can produce blue-green algae blooms. The algae produces a toxin that can cause chronic or acute poisoning.

Symptoms of poisoning develop very rapidly and resemble an allergic reaction. Animals are usually found dead at the water's edge or only a few metres away. In acute poisonings, the animal suffers from intestinal problems, internal bleeding and paralysis leading to respiratory failure.

Small amounts of poison cause weakness and staggering. In some instances, apparent recovery from an attack is followed in a few days or weeks by evidence of photosensitization. There may be inflammation of the muzzle, the skin of the ear, the udder, or other parts of the body. Jaundice is often seen, and constipation is a common symptom. Such cases usually recover under good care.

LIVESTOCK WATERING SYSTEM ALTERNATIVES

The problem of fecal bacterial contamination of some rural drainage systems can largely be attributed to livestock contact with streams while watering. As maintaining an adequate supply of clean water is an important part of herd management, fencing livestock from streams and providing an alternate water source will benefit herd health and the environment.

Restricted access points are ineffective in curbing bacterial inputs, though streambank erosion may be reduced. Elimination of all livestock contact by using buffer strips is the only way to solve watercourse contamination problems of this type.

A watering system alternative may be required out of concern for herd health, the downstream environment, or just a need for a better water supply. If rural hydro is unavailable or water supply is a problem, the information that follows may be of assistance when planning the best use of available resources. The two parts of the system that will require some consideration are the water source development and transfer mechanisms.

ALTERNATIVE WATER SOURCE DEVELOPMENT

SPRINGS

The purpose of spring development is to increase the flow of water, improve its accessibility and prevent contamination. As part of the development plan, observations of the spring area must be made during a dry period to determine the reliability of the source.

The aquifer material delivering water to the surface should be examined. Combined with knowledge of local landform and drainage patterns, assumptions may be made on the hydrogeological conditions influencing flow.

Flow may be increased through the removal of material obstructing the upwelling flow at the spring outlet. Surface runoff should be redirected to avoid the accumulation of debris and contaminants. It may be possible to collect the flow from several outlets or along a seepage face. A graded ditch, exposing the length and depth of the aquifer, can collect water with gravel fill, tile or perforated pipe and drain to a central spring box. Filter fabrics should be utilized where fine-grained soils may cause clogging.

More extensive works involving the lowering the outlet elevation or excavation to increase aquifer drainage may adversely affect local groundwater supply and should be undertaken with caution.

SEEPAGE AREAS

A means of collection and transfer to the point of use is required when utilizing seepage or areas of permanent high groundwater. Collectors can be constructed as an interceptor drainage network with the extent and complexity dependent upon the aquifer characteristics and water requirements.

Seepage planes should be located with an auger or backhoe. Tile or perforated pipe can be laid in a gravel-filled trench at right angles to the flow of groundwater, at the appropriate depth to intercept flow. Elaborate drainage layouts may involve several interceptor lines across the slope with a primary drain delivering water to a springbox.

The springbox acts as a sediment trap and facilitates maintenance of the system. Constructed of concrete or galvanized metal, the springbox should have a tight fitting lid to prevent contamination.

OFF-STREAM PONDS

Excavated off-spring ponds are the only type that should be utilized for stock watering since they will not affect or be effected by local stream water quality. Ponds may be fed by surface runoff, groundwater aquifers or both. Drainage tiles may be intercepted and directed into a pond if good water quality can be assured. Runoff water quality is largely dependent upon land management (cropping and tillage) in the drainage area.

Surface-fed ponds utilize natural depressions in broad drainageways to collect runoff. Where a shallow aquifer or permanent high water table exists, a groundwater fed pond may be practical.

A soil investigation is important prior to excavation and can be accomplished with a backhoe or auger. Runoff-dependent ponds must be located in impervious soils of high clay content to prevent seepage. Test holes can be filled with water to observe soil permeability characteristics. Artificial linings of bentonite clay or synthetic materials may seal ponds in pervious sand or gravel soils but increase expense and complication. Nearby ponds are good sources of information on local conditions.

Aquifer or groundwater-fed ponds also require test holes to evaluate the water-bearing material. The level of water in the test hole usually indicates the finished pond level. Pumping out the test hole and observing the recovery rate will give you an idea of the potential yield of the aquifer. As water tables vary with season, dry-period observations are important to avoid being misled by temporary conditions.

WELLS

Well placement is best determined by discussing it with a competent well driller. Local well logs will provide information on subsurface conditions and groundwater characteristics.

When suitable, the well should be located in an accessible area which is convenient to pastures and near a storage reservoir if needed. If gravity flow to the point of use is possible, the well should be located accordingly.

WATER TRANSFER MECHANISMS

GRAVITY

The ability of water to flow from higher to lower elevations makes a gravity system the one to utilize whenever possible. With no moving parts or energy inputs, these systems can provide dependable, low-maintenance service (Figure 23).

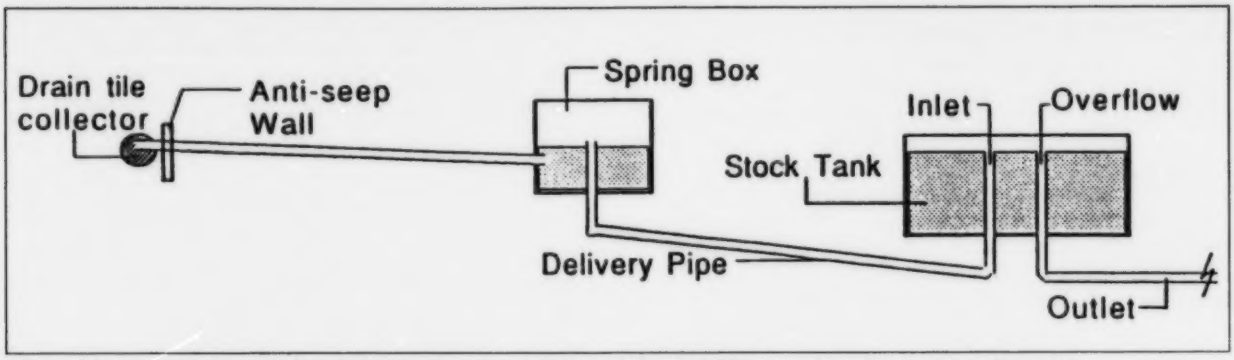


Figure 23. A gravity-powered watering system is a simple and dependable way of getting water to livestock.

To allow for flow resistance in the pipe, a minimum delivery pipe diameter 1 1/4 inch should be used where the grade is over 1%. For grades between 0.5 and 1.0%, a 1 1/2 inch minimum size is recommended. Grades less than 0.2% are not recommended for gravity systems.

The delivery pipe should be laid on a uniform grade to prevent the formation of airlocks. Pipes should be installed below the frost line and brought vertically through the bottom of the watering tank. The outlet pipe is best located close to the inlet, as the turbulence created will help to prevent freezing. Tank volume should reflect livestock numbers and water demand. The tank area should be improved for stability (i.e. gravel) in order to withstand herd traffic. A shade canopy over the tank will help to control seasonal algae growth.

SOLAR POWER

Photovoltaic (PV) panels can be used to power pumping systems for a wide range of output requirements.

Photovoltaic systems can be very reliable and low in maintenance but are expensive and require good design for practical service.

Two system designs can be utilized depending upon the application. Both systems involve the storage of energy to compensate for variances in solar radiation intensity (Figure 24).

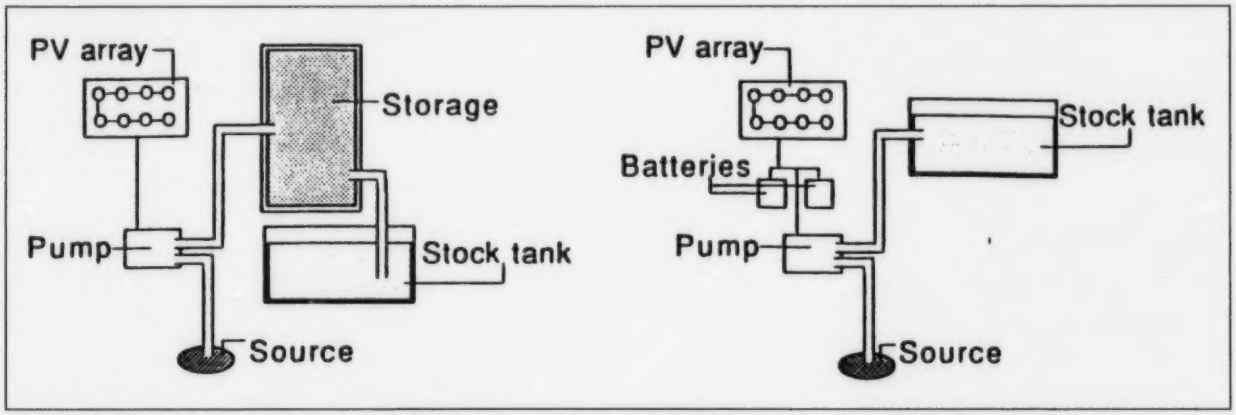


Figure 24. Two Solar System Designs: The sun's energy can be collected to power water pumping systems.

Systems utilizing energy storage in the form of pumped water held in an elevated reservoir have the advantage of design simplicity. Photovoltaic panels supply power to the water pump through a maximum power point device to deliver water to the reservoir only during periods of bright sunlight. Water from the reservoir is gravity fed to the stock trough and controlled by a float valve.

Battery systems also store energy for periods of low sunlight intensity but in chemical form. Through a sequencing device, photovoltaic panels charge the batteries which power the water pump. Pump operation is controlled by an electric float switch to allow flow on demand to the stock trough.

HYDRAULIC RAMS

Hydraulic rams (Figure 25) operate on the power of falling water. These pumps can offer practical and reliable service but require an appropriate location, good system design and proper installation.

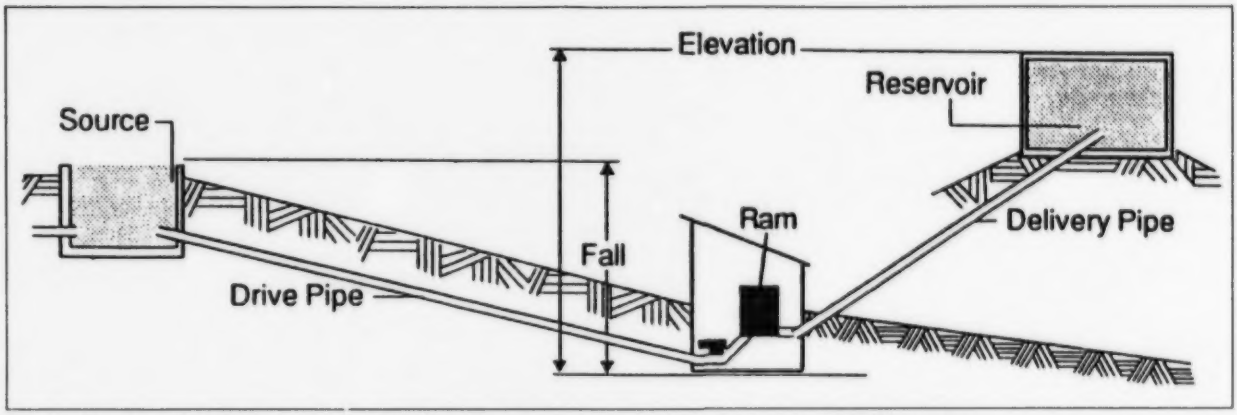


Figure 25. A typical Ram pump installation. Ram pumps operate on the power of falling water.

The energy developed in an amount of falling water drives a much lesser amount to an elevation above the source of supply. The volume of water that a ram will pump depends on the fall between the source of supply and the ram, the height to which the water is to be raised and the quantity of water available.

For livestock watering, a small stream makes an excellent source of supply. A fall of 20 inches or more is sufficient to drive a ram capable of pumping water to a stock trough at considerable elevation and distance. As the pumping rate is constant but generally slow, a storage reservoir is necessary to accommodate high demand periods.

WINDMILLS

Windmills in the past have been a proven part of the farm enterprise and could find greater use for livestock water purposes today.

Though now a fairly expensive technology, currently manufactured windmills can offer reliability and low maintenance which is equal to their antique counterparts. Old windmills can be successfully rebuilt and may offer a practical alternative to the expense of new equipment.

Multi-bladed windmills are relatively slow turning and are best suited for a plunger-type pump. A variety of windmill size and cylinder diameter combinations are possible for different prevailing wind velocities and pumping rate requirements.

Windmills traditionally pump from wells located directly below the tower. Other intake locations are possible, providing the pump cylinder is housed to protect it from freezing and a foot valve is incorporated to maintain the prime.

As the wind is a variable energy source, a storage reservoir should be used to provide a supply for periods of low wind velocity. The location of the storage reservoir can be within any practical pumping range but the mill head must be mounted to give maximum wind exposure and be well above any obstructions.

NOSE PUMPS

Utilizing a simple pumping mechanism to draw water to a bowl, the nose pump can be a good alternative to in-stream watering. Installation is quick and easy enough to describe this as a potentially portable system for use with rotation pastures.

These systems employ a diaphragm pump, mechanically activated by a lever which moves in response to pressure exerted by an animal seeking water. The intake line incorporates a foot valve and strainer for reliable operation. The water source may be a nearby stream, pond or well of suitable quality.

A disadvantage of the nose pump is that stock must water individually, limiting practical use to about 30 animals per unit. Maximum lift from the water source elevation is 25 ft. Nose pumps are relatively low in cost and installation expense is minimal. Animals must be trained to use them.

GASOLINE ENGINE-POWERED PUMPS

Portable gasoline-powered pumps are available that offer reliable service for water transfer where other systems are impractical. When used in combination with a large storage reservoir it may be possible to limit time spend operating the pump. The major drawback with this system is the need for operator supervision during pumping and attention to the water volume in storage to assure a constant supply.

ANIMAL HEALTH PROBLEMS CAUSED BY FORAGES

GRASS TETANY

Grass tetany or hypomagnesemic tetany is a condition that occurs when an animal does not get enough magnesium daily from its diet to maintain a normal level of magnesium in the blood serum.

It is seen in adult animals sooner than young animals and most often in cows and ewes shortly after giving birth. Cows milking heavily or sheep with twin lambs or triplets are more susceptible than lower-producing animals.

The symptoms of grass tetany are usually observed 5 to 10 days after animals are turned out to pasture. Lush spring grass pastures can be low in magnesium and their high moisture content can reduce dry matter intake and therefore available magnesium intake to a critical level. Typical symptoms are: **nervousness, tremors** and **twitching, staggering, convulsions,** and **death**. Death occurs quickly, within 6 to 10 hours after the onset of the first symptoms. An animal dead from grass tetany is usually found with the ground about it churned up, foam on its mouth, and a pile of loose manure behind it. Blood serum magnesium levels can drop so quickly that it is possible for tetany to occur on the first day out to pasture.

Chronic hypomagnesemia can also take place, with the plasma magnesium level dropping slowly over a relatively long period of time. The clinical symptoms of the disorder are brought on when the animal is put under an additional stress.

The magnesium supply from pastures is affected by the botanical composition of the pasture, the stage of maturity of the plants, soil conditions and fertilizer treatments.

Legumes and herbaceous weeds tend to have a higher magnesium content than grasses. White clover is one of the best accumulators. Most of the commonly used grasses tend to have similar abilities to accumulate magnesium, with the exception of tall fescue and orchardgrass. Tall fescue is a better accumulator than most grasses while orchardgrass is much worse. With both legumes and grasses there is a decline in magnesium content as the plants mature.

Wet, cold soils increase the chances of tetany occurring. Animals should be kept off poorly drained pastures, particularly during periods of rainfall in the spring and the fall.

Fertilization can affect the magnesium content in pastures in two ways. The first is by changing the botanical composition of the pasture. Use of nitrogen on a legume-grass stand encourages grasses and can lead to a decline in the legume content. The second is by directly affecting the magnesium concentration in the plants.

Nitrogen can increase the magnesium concentration in grasses when the soil magnesium level is not limited. However, if the soil magnesium concentration is low and there is a high potassium concentration, high nitrogen fertility may result in an excessive uptake of nitrogen and potassium and a reduced uptake of magnesium. Heavy potassium fertilization, alone, may also decrease magnesium uptake by plants growing in soil low in magnesium. **Soil testing to determine the potassium and magnesium soil levels before fertilizing is an important step in preventing grass tetany.**

Other options to prevent grass tetany include feeding supplemental magnesium, offering hay before the animals are turned out onto lush grass pastures, avoiding high rates of nitrogen by applying split applications and applying potassium in the fall rather than in the spring.

If grass tetany is suspected a veterinarian should be contacted as soon possible.

NITRATE POISONING

Nitrate is a normal plant metabolite. In a ruminant's digestive tract nitrates are broken down into nitrites and ammonia. Toxicity may occur when the rate of production of nitrites exceeds the rate of conversion to ammonia. The formation of large amounts of nitrites is dangerous to the animal. Nitrite is absorbed into the bloodstream where it reacts with the blood's haemoglobin to form methaemoglobin. This compound is incapable of releasing oxygen and in lethal cases the animal is killed by oxygen starvation. Cattle are more susceptible to nitrate poisoning on pasture than sheep, goats, or horses. Stressed animals are more vulnerable to nitrate poisoning.

The symptoms of acute poisoning are **trembling, staggers, rapid breathing** and **dark-looking mucous membranes. Death can occur in as little as 3 to 4 hours.** Non-fatal poisonings can cause **poor growth, poor milk production** and **abortions.** Vitamin A storage is also affected in cattle. **Contact a veterinarian as soon as nitrate poisoning is suspected.**

Normally nitrate levels are low in the grasses and legumes that are commonly used in pastures. However, occasionally there can be sufficient nitrate accumulation to cause poisoning. Several factors influence nitrate accumulation by plants:

1. Environmental conditions such as drought, uneven rainfall distribution, long periods of cloudy weather, high temperatures, and frost increase nitrate accumulation by slowing down the plants' normal growth rate. If conditions for plant growth improve and the plants start actively growing, some of the accumulated nitrates will be used up and the danger of poisoning decreased.
2. Some plants are naturally good accumulators of nitrates. These include species commonly used for annual pastures (small cereals, sorghum, sudangrass, forage rape, and kale) and weeds such as lamb's quarters, thistles, pigweeds and witchgrass.
3. Nitrate levels are highest in vegetative plants with the peak in nitrate accumulation tending to be just before the plants start to bloom.
4. There is a direct response in plant nitrate levels to increasing levels of nitrogen fertilizer. High nitrogen rates on grass pastures can cause some grass species (orchardgrass, tall fescue, meadow foxtail and reed canarygrass) to accumulate unsafe levels of nitrates. Nitrate accumulation is also greater with nitrate forms of fertilizer than with urea or ammonium sulphate.

It is not possible to easily predict when nitrate poisoning may occur because of the number of factors that influence nitrate accumulation in plants. To minimize the chance of poisoning, do not graze pastures containing a high percentage of plants that are good nitrate accumulators, or grass pastures treated with high amounts of nitrogen fertilizer, during or after periods of poor growth. Wait 10 to 14 days for the pasture to recover. A check on nitrate levels can be made by sending a sample (made up of pasture clippings) to a feed-testing laboratory.

Water may also be a source of nitrates to grazing animals. If nitrate poisoning is suspected, both the plants and water should be tested to determine the source of the problem.

BLOAT

Bloat results when an animal's rumen and reticulum become distended with gas. In the case of pasture bloat the gas is trapped in millions of bubbles, giving it a foamy appearance. The animal is unable to belch or burp up these small bubbles. **The visible result is that the animal's left flank starts to swell. The animal becomes uncomfortable, may kick at its belly, or get up and down more frequently than normal. Breathing becomes difficult and the animal will take shallow, rapid breaths. The tongue may protrude and there is some slobbering. Death can take place within 2 to 3 hours after the consumption of the bloating forage.**

Bloating normally occurs on lush pastures with a high alfalfa or clover content but can also happen when animals graze cereal crops, forage rape, and young grass pastures with a high protein content. Alfalfa and ladino clover are considered more hazardous than white Dutch, red or alsike clovers.

Cattle appear to be more susceptible to bloat than other ruminants. In addition, some individual animals are more likely to bloat than others.

The bloat hazard may be reduced in a number of ways:

- Plant pasture mixtures that do not have high percentages of bloat-causing legumes. Cattle pastures should have a maximum of 30% bloat-causing legumes while in pastures for other ruminants the amount should not exceed 50%.
- Use birdsfoot trefoil. It is the only commonly used legume that does not cause bloat.
- **Never turn hungry animals onto suspect pastures.** Feed hay to animals before they enter the pasture to prevent them from gorging on bloat-causing plants.
- Introduce animals to pastures with bloat-causing legumes for a short time. Gradually lengthen the time the animals may remain in the field over a few days.
- Introduce animals to suspect pastures when the plants are dry. Heavy dew or moisture from rain increases the chances of bloating taking place.
- Wait until bloat-causing plants are flowering before grazing. Vegetative plants and legumes in pre-bud to bud stage are more likely to cause bloat.
- Use rotational grazing to maintain a steady rate of feed intake and to reduce selective grazing.
- Wait a few days after a killing frost before grazing suspect pastures. The risk of bloat occurring increases immediately after a killing frost.
- Use an anti-foaming agent such as Poloxalene when the potential for bloat is great.

Bloat can happen at any time during the grazing season. A close watch is needed at all times, as the bloat-producing potential of a pasture can change quickly.

Bloated animals must be treated quickly. With the first signs of bloat, remove the animals from the pasture and consult a veterinarian. Keep the animals on their feet and dose the animals with an anti-foaming agent or surfactant such as mineral oil, raw linseed oil or liquid dishwashing detergent. In severe cases, when the animal has gone down and death is imminent, it is necessary to puncture the rumen and allow the gas to escape.

INFERTILITY DUE TO PHYTO-OESTROGENS

Phyto-oestrogens are plant compounds found in legumes that can cause temporary to permanent infertility in animals. They can reduce not only the number of successful matings but also the number of multiple births and cause an increase in uterine prolapses. Phyto-oestrogen activity varies with the legume species, the plant strain and with growing conditions.

In Ontario, red clover is the legume that is usually associated with causing temporary infertility problems. Red clover contains a class of fertility depressant compounds called isoflavones. The leaves of red clover are very high in isoflavone content while the stems and petioles have lower levels. Isoflavones can cause infertility in sheep, but appear to have little activity in cattle.

Ewes should be kept off pasture or not fed silage for at least a month prior to flushing and mating if the feed contains more than 30% red clover. If more than 80% of the forage is red clover, problems with return to service and barrenness may occur. Varieties of red clover with reduced levels of isoflavones are not, at present, adapted for use in Ontario, thus a predominantly red clover-based feed is not recommended for the breeding flock.

Alfalfa, white clover and birdsfoot trefoil do not contain isoflavones. However, with severe insect or disease damage, these legumes can produce compounds called coumestans which are also highly oestrogenic. Planting legume varieties with good resistance to insects and diseases, proper grazing and fertility management, and growing legumes in mixtures with grasses helps to remove coumestan fertility problems associated with sheep.

REED CANARYGRASS

The old varieties of reed canarygrass are known for being unpalatable and tough. Animals grazing the old varieties do not gain as well, produce as much milk, or appear as thrifty as would be expected based on the apparent feed quality. The cause is high levels of plant alkaloids. Alkaloids are bitter-tasting substances that are generally irritating to be gastrointestinal tract. New varieties of reed canarygrass have reduced levels of alkaloids. Feed quality, grass palatability and animal performance are excellent when these new varieties are pastured in the vegetative plant growth stage.

TALL FESCUE

A fungal endophyte in tall fescue is thought to be responsible for causing three animal disorders: fescue foot, bovine fat necrosis and fescue toxicity. The occurrence of any of these conditions is determined by the percentage of infected tall fescue plants in the pasture, the length of time the animals spend grazing infected tall fescue, the weather, and pasture fertility management.

Fescue foot can occur when animals graze tall fescue in cool weather. The symptoms include a rough hair coat, loss of weight, fever, quickened respiration rate, tenderness of the legs and, in advanced cases, loss of hooves, ears and the tail.

Bovine fat necrosis is characterized by an accumulation of hard masses of fat along the alimentary tract. This condition results in digestive upsets and problems in giving birth. Pregnant horses grazing infected tall fescue do not prepare for foaling and may give birth to a deal foal. Pregnant mares should be removed from infected fields 30 days prior to the expected foaling date. Bovine fat necrosis is associated with fertilizing infected tall fescue pastures with high rates of nitrogen fertilizer or with broiler litter.

Fescue toxicity occurs during hot weather. The symptoms are poor gains, lowered conception rates, intolerance to heat, failure to shed the winter hair coat, fever, excessive salivation, and nervousness.

The only known means of spread of the endophyte is by infected seed. It is possible to prevent these associated animal disorders from occurring by using certified endophyte-free seed or by just using a small percentage of tall fescue in the pasture.

PRUSSIC ACID POISONING

Several plant species contain glycosides that can poison animals. Cyanogenic glycosides can be found in wild cherries, marsh-arrow grass, a few strains of New Zealand white clover and in plants in the sorghum family. The amount of cyanogenic glycosides found in these plants is influenced by plant genetics, stage of growth and environmental conditions.

When ingested cyanogenic glycosides form prussic acid which is highly toxic. The prussic acid interferes with the exchange of oxygen from the lungs to the body tissues. The symptoms of acute poisoning are **muscle tremours, difficult, rapid respiration, and convulsions. Death can occur so quickly that the other symptoms are not observed.**

The highest levels of glycosides are usually found at early stages of plant growth. Sorghum-sudan hybrids should reach a minimum height of 75 cm and sudan grass a minimum of 45 cm before they are grazed.

Environmental stress of any kind can increase the amount of cyanogenic glycoside to hazardous levels. After stresses such as drought, long periods of cloudy weather or frost, do not graze sorghum for at least a week. A check on cyanogenic glycoside levels can be done at a feed-testing laboratory.

SORGHUM-SUDAN HYBRIDS, SUDAN GRASS and SORGHUMS

Besides prussic poisoning (discussed above) these plants can cause urinary tract infections in horses. The symptoms are similar to colic but include bloody urine. The condition can be fatal and it is recommended that horses not be allowed to graze these plants.

MOLYBDENUM POISONING

Molybdenum is an essential mineral for both plants and animals. However, accumulations of molybdenum in toxic levels can occur in plants growing on soils rich in molybdenum or low in copper. In certain parts of eastern Ontario, particularly in Dundas and Carleton counties, there are high quantities of molybdenum in the soil. Clovers are excellent accumulators of molybdenum and this form of poisoning usually takes place on fields with a high clover content.

Cattle are more vulnerable than sheep to the adverse effects of high molybdenum levels. **The symptoms of poisoning in cattle are acute scouring, depressed milk production, weight loss, and rough, faded, black to red coats.**

Sheep can also be affected and will show symptoms of copper deficiency, as molybdenum is an antagonist to copper.

Horses are tolerant to high molybdenum levels.

PHOTOSENSITIVITY

When eaten in large quantities alfalfa, red clover, birdsfoot trefoil, alsike clover and perennial ryegrass can occasionally cause sensitization of an individual animal's unpigmented skin. The affected skin area becomes swollen, reddened, itchy and in advanced stages the skin area hardens and peels away.

Alsike clover can also cause a more serious form of poisoning in horses. Affected horses show nervous symptoms, loss of appetite, emaciation and jaundice. Paralysis and death can follow.

BRASSICAS

Brassicas are useful for extending the pasture season into the late fall. However, they are not without their problems. In addition to causing bloat and nitrate poisoning, they can adversely affect the animals grazing them in the following ways.

Forage rape poisoning can occur if animals graze stunted, purple-coloured rape plants. This type of plant is produced when rape growing in wet conditions or on soils deficient in phosphate are frosted. Animals affected take **shallow, rapid breaths** and suffer from **digestive disturbances.** Death may follow. When the affected animals recover they often remain unthrifty.

Brassicas contain a haemolytic factor that may cause grazing animals to suffer from anaemia. Cattle are more susceptible to this disorder than sheep. Anaemia only develops when the livestock are grazing brassicas for at least one week and it usually takes three weeks to occur. In extreme cases, haemoglobin appears in the urine, giving it a red colour. The amount of the haemolytic factor in brassicas increases as seeding dates are delayed in the summer and with plant maturity.

All brassica crops contain goitregenic substances. The goitregen affects the uptake of iodine by the thyroid gland and goitre develops. Goitre can occur in all animals grazing brassicas but is more of a concern with sheep. Brassica pastures should not be used during the mating season or for ewes late in their pregnancy. Lambs may be born dead or deformed.

White-faced sheep grazing brassicas in August and September may suffer from "rape scald." Their light-coloured skin becomes susceptible to sunburning and their heads may swell.

Forage rape can taint the flavour of milk and meat if it is the main source of feed.

Rape "blindness" is the sudden appearance of blindness in cattle and sheep grazing rape. Complete recovery of sight normally occurs a few weeks after the livestock have had a change of diet.

It is important to limit the feeding of brassicas in order to avoid problems.

PASTURE RECORD CHART*

Year 19 _____

Field or Paddock	Pasture Species	Size	No. & Type of Livestock	Fertilizer Applied Amount & Type	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total Days
				Precipitation									
				Supplemental Feed Required									

PRODUCTION SUMMARY

Total Grazing Days _____

Amount of Hay Harvested _____

Condition of Fields at the End of the Season

Remarks on Animal Productivity and Health Problemss

Mortality

**Adapted from Manitoba Agriculture Pasture Record Chart*

GLOSSARY

Acceptability, Animal: Readiness with which animals select and eat a forage; sometimes used interchangeably to mean either palatability or voluntary intake.

Aftermath: Recovery growth of forage plants after harvesting by animal or machine.

Animal Day: One day's tenure feeding on range or pasture by one animal.

Animal Unit: One mature cow (454 kg) or the equivalent based upon average daily forage consumption of 12 kg dry matter per day.

Animal-Unit Conversion Factor: A numerical figure expressing the forage requirement of a particular kind or class of animal relative to the requirement for an animal unit. A conversion factor measures the amount of forage required to maintain an animal, but may not be applicable in determining stocking rates for range and pasture use for particular kinds of classes of animals because of different grazing preferences.

Animal-Unit Month (AUM): The amount of feed or forage required by an animal unit for one month.

Browsing: The defoliation of the above-ground parts of shrubs and trees by animals.

Canopy: The above-ground parts of a population of herbaceous plants, including connotations of the distribution and arrangement of the constituent plants and their parts.

Defoliation: The complete or partial removal of the above-ground plant parts, living or dead, by grazing animals or cutting machines.

Defoliation Interval: The time interval between successive defoliations of an area of sward or of individual plant units.

Degree of Defoliation: The ratio of the amount of herbage consumed to the original herbage mass.

Frequency of Defoliation: The number of defoliations per unit time of an area of sward or of individual plant units.

Rate of Defoliation: Herbage consumed per unit of time during a period of defoliation.

Uniformity of Defoliation: A qualitative term describing the distribution of the mass of residual herbage between adjacent areas of sward or individual plant units.

Forage Quality: Characteristics that make forage valuable to animals as a source of nutrients; the combination of chemical, biochemical, physical, and organoleptic characteristics of forage that determines its potential to produce animal meat, milk, wool, or work. Considered by some as synonymous with feeding value and nutritive value.

Forb: Any herbaceous non-grasslike plant on which animals feed.

Fouled: Pasture spots or areas made unacceptable to the grazing animal by the presence of urine or dung.

Graze: Partial defoliation of forage plants by the animal; to feed animals on growing grass or herbage; to forage.

Grazing, Continuous: The grazing of a specific range or pasture by livestock throughout a year or grazing season. The term is not necessarily synonymous with year-long grazing.

Grazing, Creep: The practice of allowing young animals (lambs or calves) to graze an area which their dams cannot reach.

Grazing Cycle: The length of time between the beginning of one grazing and the beginning of the next (= grazing period + rest period).

Grazing, Deferred: Delay or discontinuance of livestock grazing on an area for an adequate period of time to provide for plant reproduction, establishment of new plants, or restoration of vigour.

Grazing, Mixed: The use of cattle and sheep in a common grazing system, whether or not the two species graze the same area of land at the same time.

Grazing Period: The length of time for which a particular area of land is grazed.

Grazing Pressure: Number of animals per unit area of available forage.

Grazing, Rest-rotation: Intensive system of management whereby grazing is deferred on various parts of the range during succeeding years, allowing the deferred part complete rest for one year; two or more units are required.

Grazing, Rotational: System of pasture utilization embracing periods of heavy stocking followed by periods of rest for herbage growth recovery during the same season.

Grazing, Strip (Ration Grazing): Confining animals to an area of forage to be consumed in a short period of time, usually a day.

Hard Seed: With a seed coat impervious to the water or oxygen necessary for germination; common in legume seed; germination improved by scarification.

Herbage: Leaves, stems, and other succulent parts of forage plants upon which animals feed.

Herbage Allowance: The weight of herbage per unit of animal live weight at a point in time.

Herbage Consumed: The mass of herbage removed per unit area by the animals at a single grazing or series of grazings.

Herbage, Residual: The herbage remaining after defoliation.

Native Grass: Grass species indigenous to an area; not introduced from another environment or area.

Paddock: Small fenced field used for grazing purposes.

Palatable: A general term describing the discrimination exerted by animals between areas of sward or the components of a sward canopy, and between or within samples of cut herbage.

Pasture: A population of herbaceous plants, usually bounded by a fence, considered as a functional unit for grazing.

Pasture Carrying Capacity: Number of animals a given pasture will support at a given time or for a given period of time.

Pasture, Cropland: Includes rotation pasture and other land used only for pasture but that could be used for crops without additional improvements. Preferred to "rotation pasture."

Pasture, Permanent: Pasture of perennial or self-seeding annual plants maintained through several years for grazing.

Preference: A general term describing the discrimination exerted by animals between areas of sward or the components of a sward canopy, and between or within samples of cut herbage.

Put-and-Take Animals: Used in a grazing experiment to graze excess forage beyond that needed for tester animals and to accumulate animal days.

Rejuvenation: Accomplished by soil-plant-animal management practices favourable to forage plants.

Rest Period: The length of time between the end of one grazing and the start of the next on a particular area.

Selection: The removal of some components of a sward or a sample of herbage rather than others, a function of preference modified by the opportunity for selection.

Set Stocking: The practice of allowing a fixed number of animals unrestricted access to a fixed area of land for a substantial part of a grazing season.

Sod: Top few centimetres of soil permeated by and held together with grass roots or grass-legume roots.

Stocking, Continuous: The practice of allowing animals unrestricted access to an area of land for the whole or a substantial part of a grazing season.

Stocking Density: The number of animals of a specified class per unit area of land actually being grazed at a point in time.

Stockpiled: Accumulated growth of forage for later use.

Sward: A population of herbaceous plants, characterized by a relatively short habit of growth and relatively continuous ground cover, including both above- and below-ground parts.

Topdressing: Application of fertilizer anytime after establishment of a crop.

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Factsheets:

118/10	*Winter Triticale in Ontario*
120/31	*Selecting a Perennial Forage*
121/21	*Stop Alfalfa Winterkill*
122/20	*Birdsfoot Trefoil Production*
130	*Pasture Legumes Identified*
133	*Annual Forages for Pasture*
460/10	*Hay and Pasture for Horses*

SOIL FERTILITY AND FERTILIZER MANAGEMENT

Factsheets

530	*An Introduction to Soil Fertility*
541	*Use of Stabilized Sewage Sludge on Agricultural Land*
120/530	*Fertilizer Use in Forage Establishment*
121/531	*Boron Fertilization of Alfalfa*
121/542	*Fertilizer Practices for Alfalfa Production*

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Publication 505, *Ontario Weeds*
Publication 75, *Guide To Weed Control*

Factsheets

130/643	*Common Weeds Poisonous to Grazing Livestock - Part A*
130/643	*Common Weeds Poisonous to Grazing Livestock - Part B*
130/643	*Poisoning of Livestock by Plants*
640	*The Annual Nightshades*

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Factsheets

400/724	*Electric Fencing for Sheep*
400/724	*Farm Pasture Fencing*
400/724	*Suspension Fencing*

HEALTH AND WELFARE OF GRAZING ANIMALS

Factsheets

400/716	*Water Requirements of Livestock*

Dairy

Factsheets

410/653	*Fly and Louse Control on Dairy Cattle*

Beef

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420/65	*Minerals and Vitamins for Beef Cattle*
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430	*Feeding The Ewe*
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430/667	*Prevention and Control of Disease in Sheep Flocks - Part A*
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PASTURE RENTAL AGREEMENTS

Factsheets

812	*Farm Lease Agreement - Pastureland*

STRUCTURES

Factsheets

572	*Low Level Crossings*
573	*Livestock Watering Devices*

Agricultural Engineering Leaflets

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1811	*Corral and Feedlot Fencing*
1812	*Crowding Gate*
1813	*Working Chute*
1814	*Blocking Gates*
1816	*Stationary Adjustable Loading Chute*
1817	*Adjustable Loading Chute*
1831	*Minimum Working Corral*
1835	*Large Working Corral*
2663	*Mineral Feeding Box*
4613	*Fixed Mineral Box*
4614	*Portable Mineral Box*
4811	*Sheep Corral Unit*
4812	*Working Chute*
4813	*Sheep Corral Fencing and Gates*
8362	*Texas Gate (Vehicle Pass)*
8364	*Farm Gate*
8365	*Page Wire Fencing*
8366	*Barbed Wire Field Fencing*
8367	*Barbed Wire Suspension Fencing*